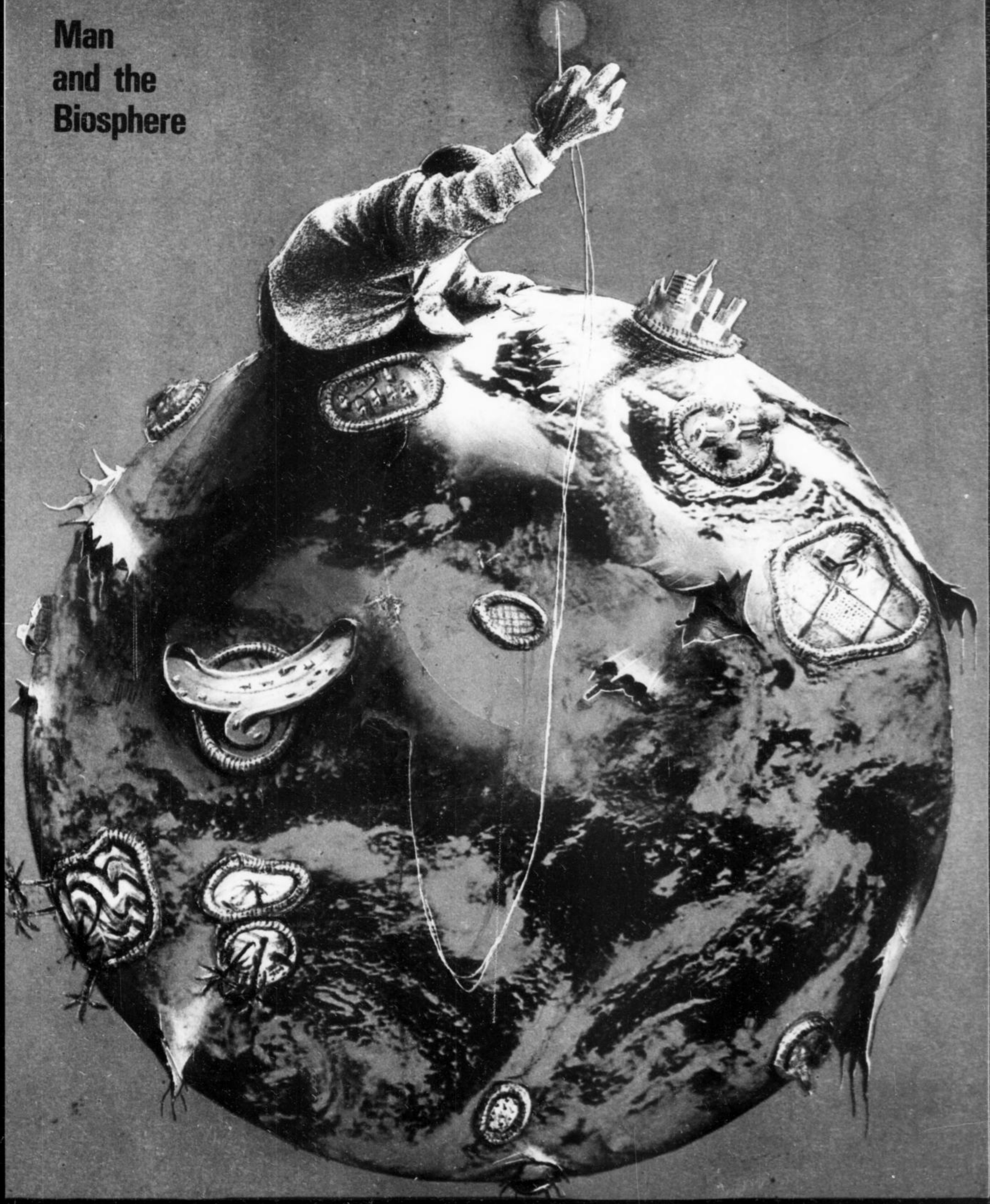
The Unesco Courier

APRIL 1981 - 4.50 French francs

Man and the Biosphere



TREASURES
OF
WORLD ART

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Chile

The bird-man

This wooden *tangata manu* ("bird-man") statuette is an example of the religious art of Easter Island. It is connected with the ancient cult of the bird-god Matemake, in which the islander who secured the first egg of the sea-swallow *manutara* became "bird-man" for a year and also exercised forms of sacred authority and political power. The body of the statuette is that of a man with skeletal ribs, but instead of arms there are folded wings and the head has a long beak. The statuette (33.7 cm high) is today preserved in the Museum of Anthropology and Ethnology at Leningrad.

Photo © Museum of Anthropology and Ethnology, Leningrad

The Unesco Courier

A window open on the world

APRIL 1981 34th YEAR

PUBLISHED IN 25 LANGUAGES

English, French, Spanish, Russian, German, Arabic, Japanese, Italian, Hindi, Tamil, Hebrew, Persian, Dutch, Portuguese, Turkish, Urdu, Catalan, Malaysian, Korean, Swahili, Croato-Serb, Macedonian, Serbo-Croat, Slovene, Chinese

A selection in Braille is published quarterly in English, French and Spanish

Published monthly by UNESCO
The United Nations Educational, Scientific and Cultural Organization

Editorial, Sales and Distribution Offices
Unesco, Place de Fontenoy, 75700 Paris

Subscription rates
1 year : 44 French Francs
2 years: 75 FF
Binder for a year's issues: 32 FF

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The Unesco Courier is produced in microform (microfilm and/or microfiche) by: (1) University Microfilms (Xerox), Ann Arbor, Michigan 48100, U.S.A.; (2) N.C.R. Microcard Edition, Indian Head, Inc., 111 West 40th Street, New York, U.S.A.; (3) Bell and Howell Co., Old Mansfield Road, Wooster, Ohio 44691, U.S.A.

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ISSN 0041-5278
No. 4 - 1981 - OPI - 81 - 1 - 375 A

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Cover

Unesco's Man and the Biosphere (MAB) Programme is ten years old this year. In this issue of the *Unesco Courier* we present concrete examples of what MAB has achieved in four major priority areas of ecological research during the past decade, a period which has seen the concept of ecology itself evolve to become an interdisciplinary, problem-oriented science, centred on man, which provides a new and realistic basis for reconciling the seemingly contradictory demands of conservation and development.

Graphic Gal © *Unesco Courier*, Paris

Man and the

The first ten years of Unesco's

by Amadou-Mahtar M'Bow
Director-General of Unesco

THIS year marks the tenth anniversary of the intergovernmental research Programme on Man and the Biosphere (MAB) which was launched by Unesco in November 1971, and whose purpose is to establish the scientific basis necessary for land use planning and for the management of the resources of the biosphere in harmony with nature.

By virtue of its scale—over a hundred countries engaged in a common effort on some thousand applied research and training projects involving more than ten thousand scientists and technicians—the Programme, now fully operational, constitutes a vast natural laboratory in which several guiding principles developed within Unesco are being tested under field conditions.

Thus, confronted with the specific problems of the environment, MAB has confirmed a fundamental precept: for science and technology to serve human

Photo Margaret Bourke-White/*Life* © Time Inc., London

Biosphere

environmental programme

progress more fully, they must be integrated into each country's culture, and the tasks which are undertaken in their name should be in keeping with that country's specific characteristics.

It has also become clear that the interdisciplinary approach which is fundamental to Unesco's action is the one best qualified to produce solutions to the highly complex problems of the environment. This is why the MAB Programme brings together specialists in the natural and the exact sciences, as well as specialists in the social and human sciences, and planners.

Another factor in the Programme's success is the participation of local populations, both in identifying priorities and in applying the results of research. Here it has been necessary to diversify the methods of presenting scientific information, so as to make it more accessible to those who will use it, as part of an education which enables man to assume fuller responsibility for his natural and cultural heritage.

The experience of the last ten years has also yielded extremely valuable results for international co-operation, which has fostered the collaboration of scientists, exchanges of information and experimental data. By stimulating and co-ordinating these operations, Unesco has performed the role it has marked out for itself as a catalyst of ideas and action.

Another original feature of the Programme is that it has produced substantial results from relatively slender resources. Its action, relayed from the small MAB secretariat to the hundreds of persons working on MAB National Committees and the thousands of specialists engaged on research and training activities, has had a multiplier effect. Likewise, Unesco's regular Programme budget, necessarily limited in comparison to needs, has served to generate funds from other sources to the benefit of Member States, or to facilitate agreements between countries, thus considerably increasing the possibilities of action.

Finally, the Man and the Biosphere Programme is an excellent example of the decentralization which Unesco is striving to promote in all its fields of activity. In this case, decentralization is almost total, since the Programme activities are carried out directly by the countries themselves. They are gradually acquiring an autonomy in this field which should enable them to continue the work they have begun, and to maintain the co-operative relations which have been established at the regional and inter-regional levels. If, ten years after its creation, the Man and the Biosphere Programme has achieved undoubted success and is continually expanding, it is essentially because the participant countries have succeeded in integrating it into their development process. ■

Photo © CIRIC, Geneva

Ecology— the genesis of a science of man and nature

by Francesco di Castri

DURING the last ten years ecology has become a fashionable word. It is used frequently on radio and in daily conversation and everybody thinks they know what it means. But do they really? Even among specialists there are considerable differences of opinion as to what ecology is supposed to be and what it is supposed to do and, hence, how it should be defined.

What exactly is ecology? A moral philosophy and a form of action for the protection of plants and animals? A political party? A protest movement against nuclear energy and pollution? A neo-Romantic yearning for a return to Nature? A scientific discipline derived from biology? Or something of all these things? Is it a philosophy, a message, a myth or a science?

There is no doubt in my mind that ecology is first and foremost a science, but to say positively when it began is a more difficult matter. If it is seen as a science with a clearly-defined corpus of knowledge and an established methodology, then ecology is of recent origin and has had an eventful history. If, on the other hand, it is considered merely as a scientific approach, it is very ancient.

The works of Roman authors such as the philosopher Lucretius, the poet Virgil or the agronomist Columella already contain elements of ecological principles. But these are also to be found in all the other ancient civilizations, and probably more frequently in the East than in the West. Stretching a point one could even say that, in order to survive the harsh climate and hunt reindeer and mammoth, cave-men had to show a more highly developed ecological sense than many modern ecologists.

The word ecology itself (from the Greek word *oikos,* meaning home, habitat) was coined in 1869 by the German scientist Ernst Haeckel who used it to define the science which studies the relationship between an organism and its environment. Haeckel, a far-sighted biologist and supporter of Darwin's theories, peppered his writings with new and often harmonious-sounding words most of which are forgotten today. "Ecology" was his most successful creation judging by its popularity and the scientific achievements it has encouraged.

Coining new words, incidentally, has been the besetting sin of generations of ecologists. The quaint, unwieldy and sometimes incomprehensible neologisms which they have invented are often an unconscious way of concealing a lack of precision in concepts and methods. These unnecessarily complicated terms certainly have not helped the different schools of ecology to benefit from one another's influence; neither have they encouraged planners to use the results of ecological research or helped to familiarize the public with ecological thought and action.

The genesis and especially the evolution of ecology were very different from those of the other sciences. Most sciences—biology is an example—could be represented as a tree trunk from which sprout a number of branches (cytology, histology, physiology) themselves subdivided into smaller and increasingly specialized ramifications (molecular biology, neurophysiology, etc). Ecology, on the other hand, would be shown as a mass of roots, all converging to form a common trunk: first botany, zoology, climatology, the soil sciences and physical geography; then biochemistry and microbiology (for studying the processes of biological production) and advanced mathematics (for model construction) and, finally, sociology, human geography, psychology and even economics.

It would be difficult to claim that this common trunk, ecology, is as consistent and homogeneous as that of the other sciences. The various disciplines that form it have not yet harmonized their approaches and interactions. Perhaps they never will completely. Yet it is this broad convergence of disciplines which gives ecology its strength, equipping it to face increasingly complex environmental problems and to deal with the multiple facets of social and natural systems in which any change, even if it is limited to a single element in the system, is bound to set off a series of chain reactions affecting all the others.

This is the crux of the dialectical debate between the two types of sciences. The analytical or reductionist sciences on the one hand which set out to dissect and dissociate the elements of a structure in order to define them and study them in depth, and, on the other, the synthetic or holistic sciences (from the Greek word *holos,* meaning whole), of which ecology is the best example, that attempt to grasp a system in its entirety by studying the interactions between all its elements.

This distinction should not be taken as a value judgment. These two scientific approaches, both equally important, are by nature complementary and this might well be better reflected in practice.

The fact remains that during recent decades the reductionist sciences (molecular biology, biochemistry and biophysics) have taken overwhelming precedence over ecology and the natural and human sciences, not only in the financing of research, but also as regards academic and social prestige and in science planning. In order to reverse this trend ecology must prove much more convincingly than in the past its *raison d'être* in terms of present-day science and society.

I have not attempted to give a precise definition of ecology and its achievements because its research methods and even its goals are developing so fast that any static formula describing a single moment in its evolution would appear forced and artificial.

Instead, I will try to tell the fascinating story of a branch of science which has always been trying to find its way, especially during the last twenty-five years, but which has now begun to find its true vocation

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FRANCESCO DI CASTRI *is director of Unesco's Division of Ecological Sciences. A biologist, he was formerly Professor of Animal Ecology at the University of Chile, at Santiago, and director of the Institute of Ecology of Valdivia, Chile, which he founded in 1969. He was an active participant in the International Biological Programme and was the first vice-president of the Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU). He assisted in the preparation of the United Nations Conference on the Environment, held at Stockholm in 1972, and has been Secretary of the International Co-ordinating Council of Unesco's Man and the Biosphere Programme since it began in 1971.*

bringing together in one single study the co-evolution of man and nature.

At the beginning of the present century, ecology was still a descriptive study of nature, a sort of natural history which drew inspiration from the works of the great 19th century explorers and naturalists. Among these was the Frenchman Jean-Henri Fabre whose *Souvenirs Entomologiques*, written between 1870 and 1889, still impress the reader with their accuracy of observation and their lyrical descriptions of natural phenomena. Before long, however, more detailed studies were tc be made of the environment in which given species live, and of their symbiotic and antagonistic relationships with other species. This *auto-ecology*, or ecology centred on a single species, had and still has important applications, in particular in the biological control of plant pests, research on disease carriers and the prevention of parasite-borne infections.

But each species, even when studied in conjunction with those that influence it directly, is only a tiny instance among the thousands of plant, animal and microbial species which inhabit a given area—a forest, a pond or a beach. This realization led to the development in the mid-1920s of *synecology*, that is to say the ecology of communities of species. (In this connexion special mention should be made of the names of August Thienemann, J. Braun-Blanquet and Charles Elton.)

Basic concepts began to be applied, such as the "food chain" and the "pyramid of numbers", in which the number of individuals decreases progressively from plants at the base to herbivorous and predatory animals at the summit. Vito Volterra, G.F. Gause and Umberto D'Ancona put forward mathematical laws governing the population dynamics of interacting groups of species. These studies proved especially useful in aquatic ecology where they helped to solve problems related to sea fishing and to promote understanding of phenomena such as insect invasions.

The publication in 1949 of *Principles of Animal Ecology*, a collective work by five American authors—W.C. Allee, Alfred Emerson, Orlando Park, Thomas Park and Karl Schmidt—drew attention to two important trends, one positive, the other negative. It demonstrated that ecology in its wide-ranging disciplines had adopted a strictly scientific approach. But it also showed that the new science was dissipating its efforts in too many different directions, and above all that it lacked a basic study unit similar to the atom in physics, the cell in cytology, the tissue in histology or the organ in physiology.

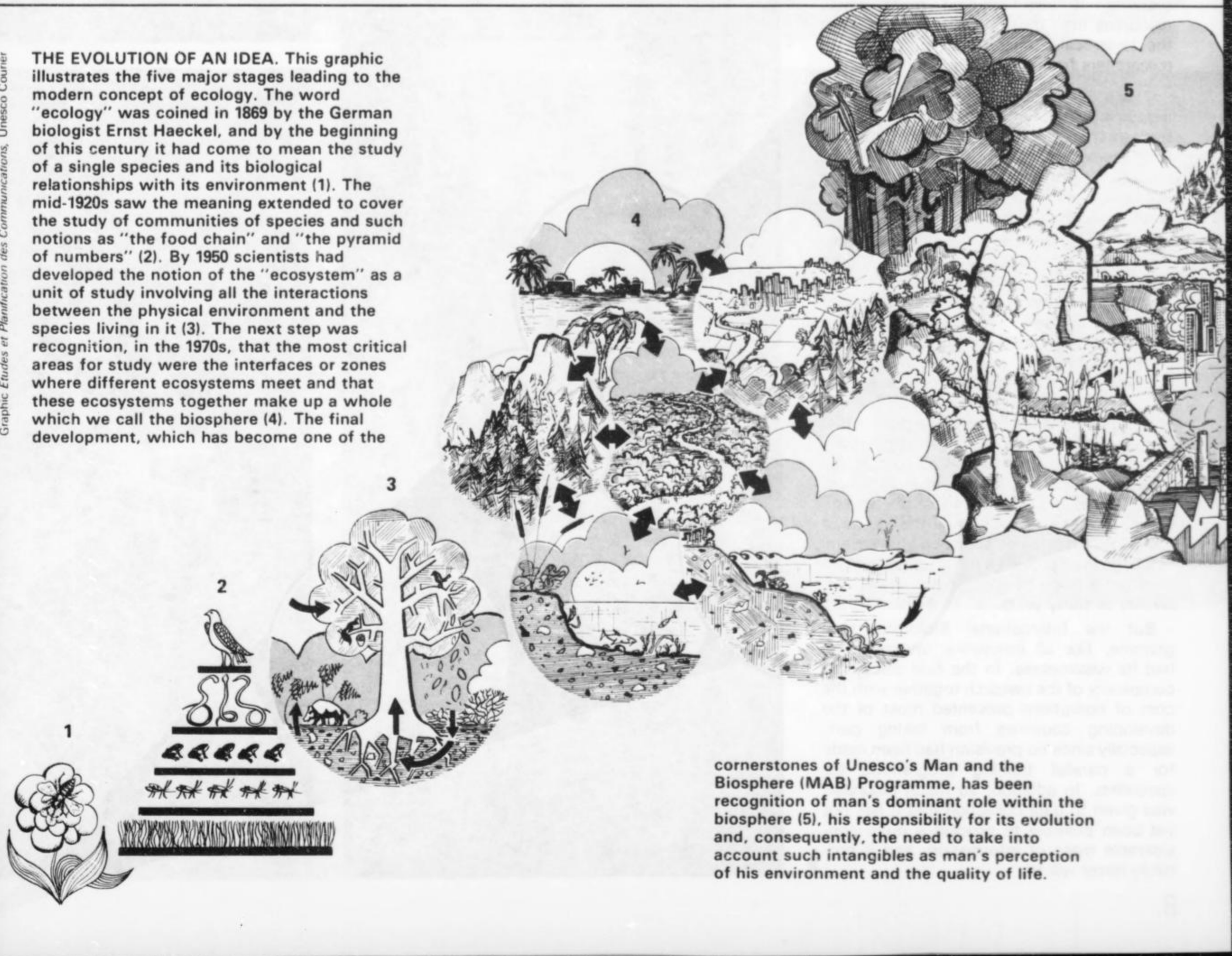
This study unit was to be the *ecosystem*. It can be described as an entity precisely defined in space and time which includes not only all the organisms inhabiting it, but also physical conditions of climate and soil, as well as all interactions between the different organisms and between these organisms and physical conditions.

An example of an ecosystem would be a tropical forest, at a given place and time, with thousands of plant, animal and microbial species living in its soil and air space with millions of specific interactions taking place between them, the various influences exercised on the life of these innumerable beings by climate and soil, and the changes the latter undergo as a result of the organisms' activities and of the very existence of the forest.

The term ecosystem was first proposed in 1935 by Arthur George Tansley. And in 1942 Raymond Lindeman pioneered the conceptual and methodological bases for studying these highly complex systems: the energy flows and the nutritional cycles which pass through all the living and non-living components of the ecosystem.

The story of Lindeman—who died at the age of 27 before his twenty-page paper appeared posthumously in the journal *Ecology*—illustrates the constraints to which the progress and development of a science can be subjected. In this particular case, the constraints were imposed by the scientific establishment itself. His article, which has influenced ecological theory over the last thirty years and is regarded today as a classic, was first turned down by the journal's scientific advisers. Lindeman was too far ahead of his time.

It should be noted that other authors, especially the Russians and Germans, have also suggested terms which to some extent



Graphic *Etudes et Planification des Communications*, Unesco Courier

THE EVOLUTION OF AN IDEA. This graphic illustrates the five major stages leading to the modern concept of ecology. The word "ecology" was coined in 1869 by the German biologist Ernst Haeckel, and by the beginning of this century it had come to mean the study of a single species and its biological relationships with its environment (1). The mid-1920s saw the meaning extended to cover the study of communities of species and such notions as "the food chain" and "the pyramid of numbers" (2). By 1950 scientists had developed the notion of the "ecosystem" as a unit of study involving all the interactions between the physical environment and the species living in it (3). The next step was recognition, in the 1970s, that the most critical areas for study were the interfaces or zones where different ecosystems meet and that these ecosystems together make up a whole which we call the biosphere (4). The final development, which has become one of the cornerstones of Unesco's Man and the Biosphere (MAB) Programme, has been recognition of man's dominant role within the biosphere (5), his responsibility for its evolution and, consequently, the need to take into account such intangibles as man's perception of his environment and the quality of life.

cover the concept of the ecosystem. But these words were not very successful, partly because they were often unwieldy and partly because works on ecology and specialized journals were written predominantly in English. Eugene P. Odum's book, *Fundamentals of Ecology*, in particular, published in 1953 and translated into several languages, greatly contributed to the success of the term ecosystem.

The ecosystem concept, moreover, is in line with Ludwig von Bertalanffy's General Theory of Systems; the whole represents more than the sum of its constituent parts, since its main feature is the interaction taking place between its various elements.

During the 1950s and the first half of the 1960s the application of this concept led to studies on the efficiency of energy capture and entry into the ecosystem through the photosynthesis process, on the efficiency of the transformation of matter as it passes from one link in the chain to another, and on the recycling and recovery of nutrients in the "soil compartment". These studies helped to elucidate the phenomena responsible for the biological productivity of the ecosystem. Analogies between the functioning of an ecosystem and the metabolism of an organism have enabled researchers to grasp the relationships between different levels in the organization of life.

However, the study of an ecosystem in its totality called for a more sophisticated research tool, which was to be supplied as a result of progress in computer technology and information processing that made it possible to construct models of complex systems. It also required more ample resources than those hitherto available and the large-scale organization of groups of researchers from different disciplines.

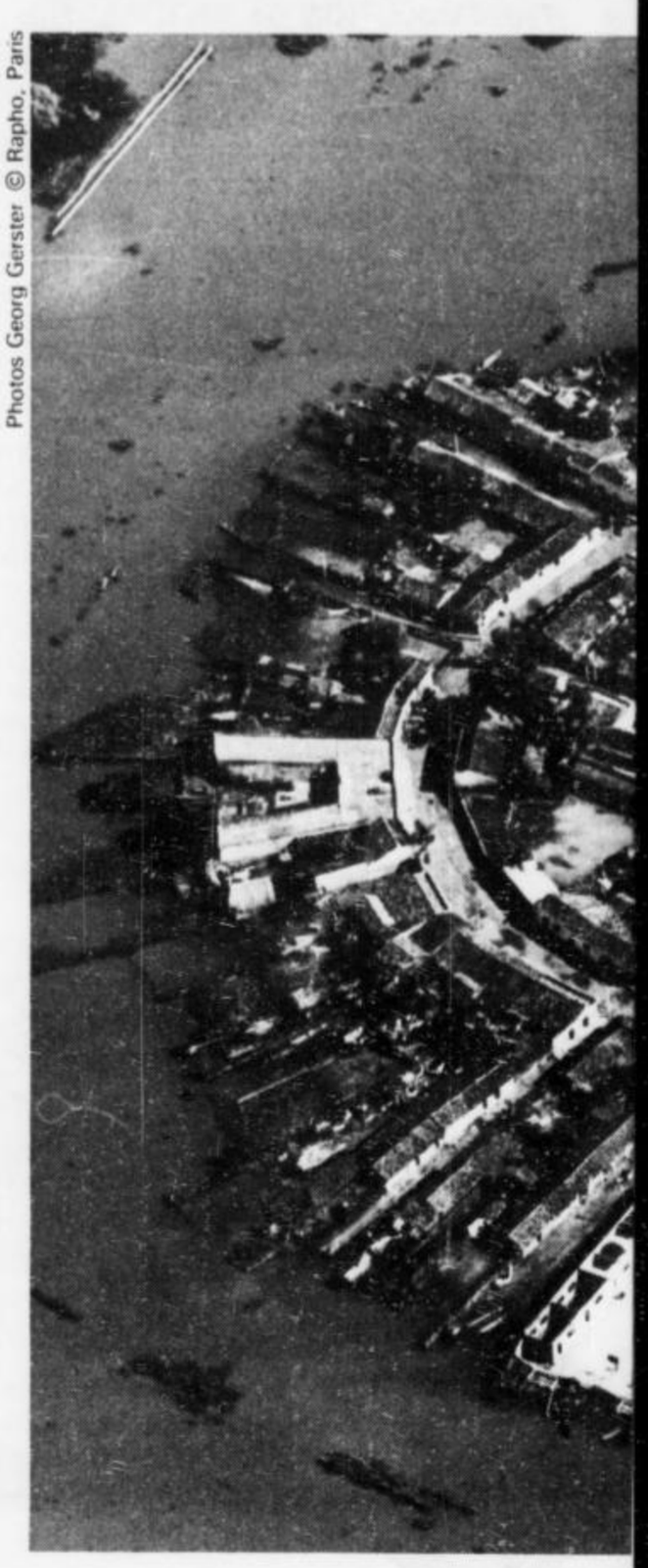
These three conditions existed in several industrialized countries and led to the implementation of the International Biological Programme (1964-1974). This was the period of Frank Blair's *Big Biology* and ecological research carried out on a far larger scale than ever before.

The achievements of the International Biological Programme (IBP) were undeniable. The methodologies developed for the Programme have been adopted almost universally. And specialists are beginning to understand the functioning of certain ecosystems, particularly the simpler systems of the tundras, certain lakes and deserts, coniferous and deciduous forests, and steppes and temperate zone grasslands. But research has come up against great difficulties in studying systems as complex as those of tropical rain forests, or as varied as, for example, Mediterranean scrub. In any event, the series of reports on the results of the IBP that have appeared in several languages will provide a basis for understanding the biology of ecosystems in the next twenty or thirty years.

But the international Biological Programme, like all innovative undertakings, had its weaknesses. In the first place, the complexity of the research together with the cost of operations prevented most of the developing countries from taking part, especially since no provision had been made for a parallel training programme for specialists. In addition, so much emphasis was given to data collection that it has not yet been possible to process a quite considerable mass of information, and it probably never will be.

MaB

Photo Unesco-Documentation Centre on Ancient Egypt, Cairo



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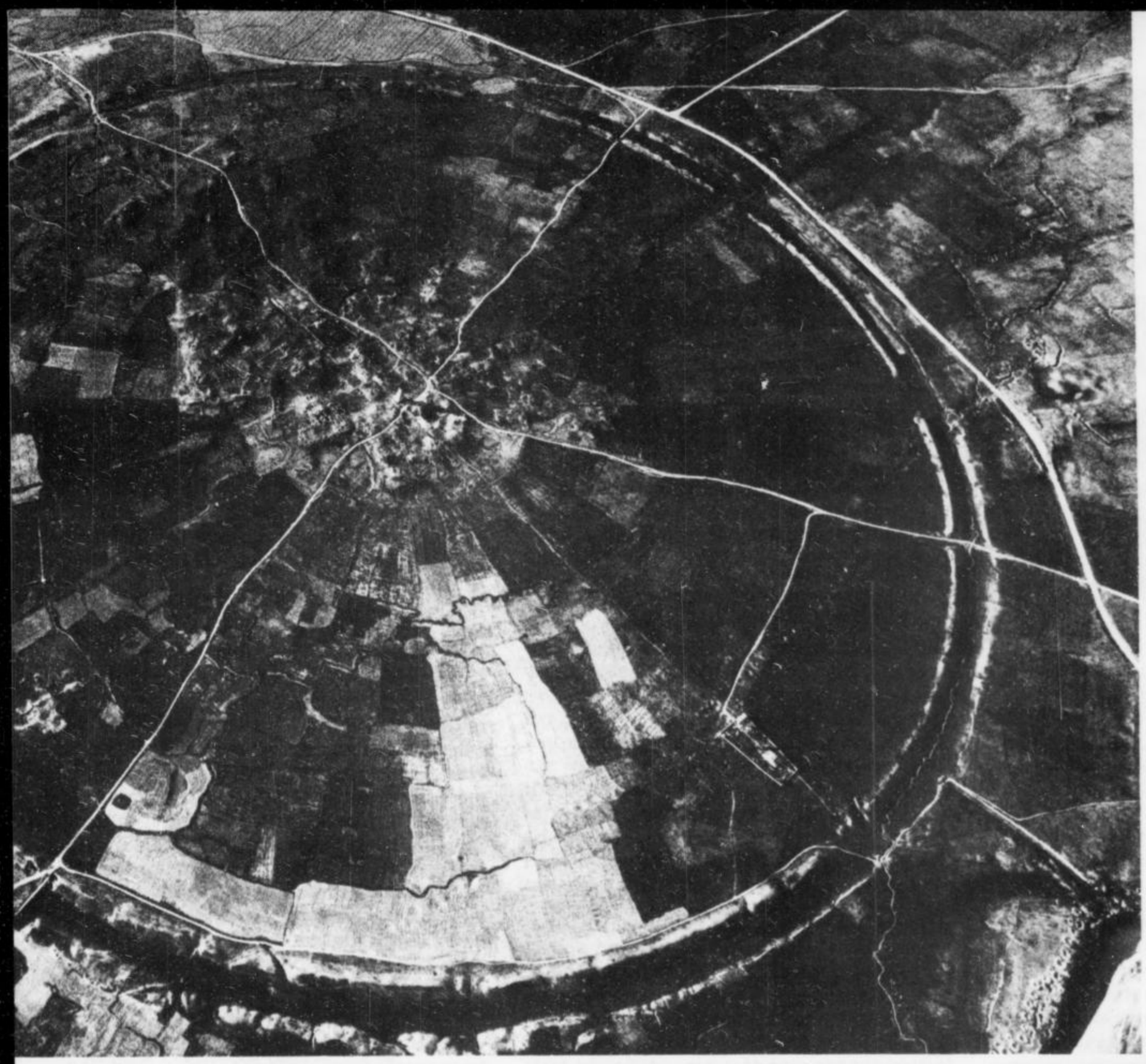
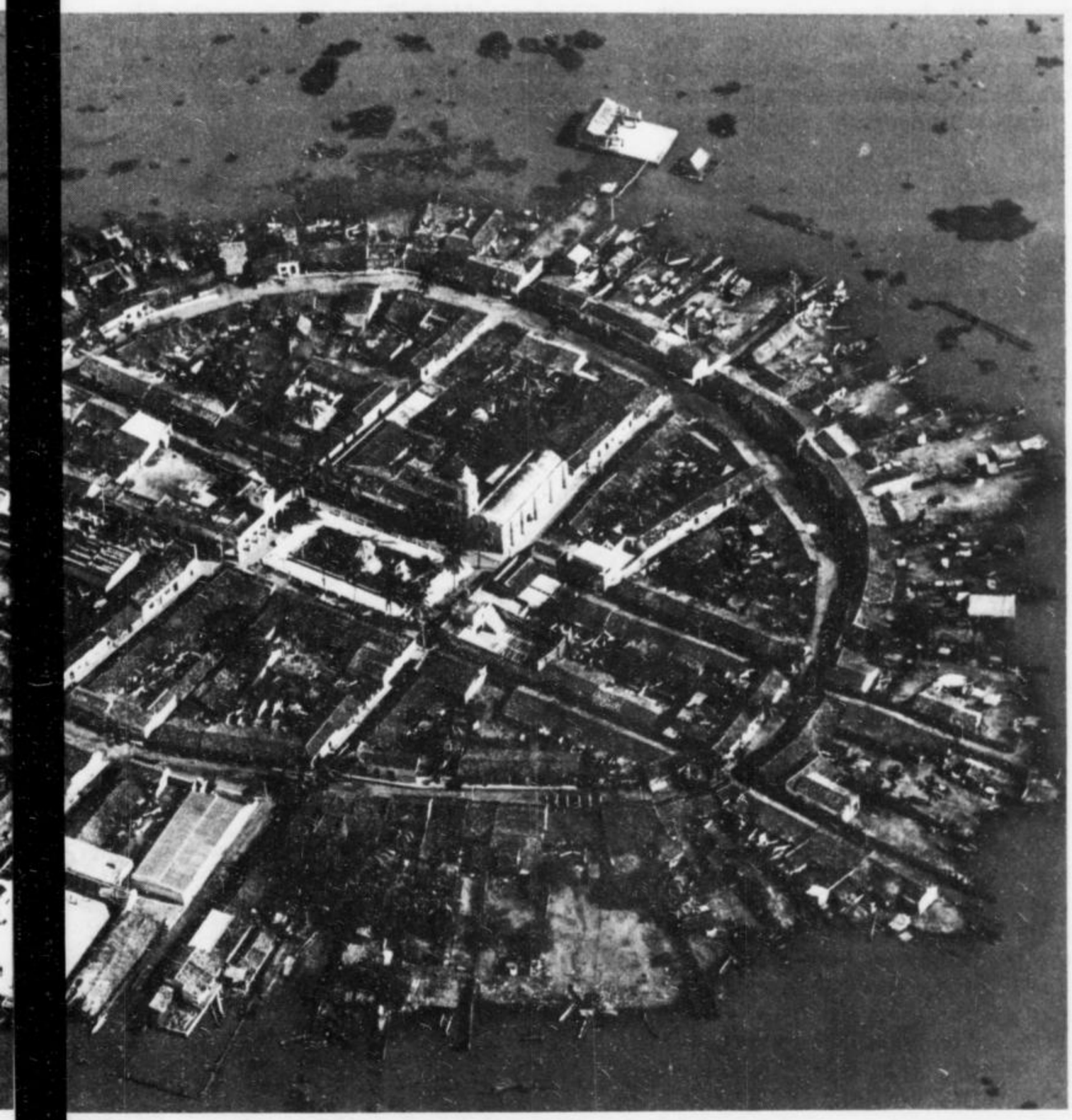


A stylized version of the ancient Egyptian sign for life (the "ankh", held by the Pharaoh Tuthmosis III in the stone effigy, opposite page) is incorporated into the symbol of Unesco's Programme on Man and the Biosphere. The sacred bond which in former times united man to the earth, considered as a divinity, appears symbolically in certain landscapes shaped by man and in branches of traditional knowledge such as the Chinese *feng-shui,* which held that human activity should accord with the interests of nature. Left, the ancient Sassanian circular city of Gur, near modern Firuzabad or Fars, in Iran. Dating from the 3rd century AD, its plan is a reflection of the spherical universe of ancient cosmology. Below left, a Mexican fishing village built on a lagoon on the Pacific coast. The compass, below, enabled a Chinese practitioner of *feng-shui* to determine the appropriate sites for tombs, temples or dwellings, and the best way to use land. Circles on the face correspond to the points of the compass, astrological influences and features of the landscape.



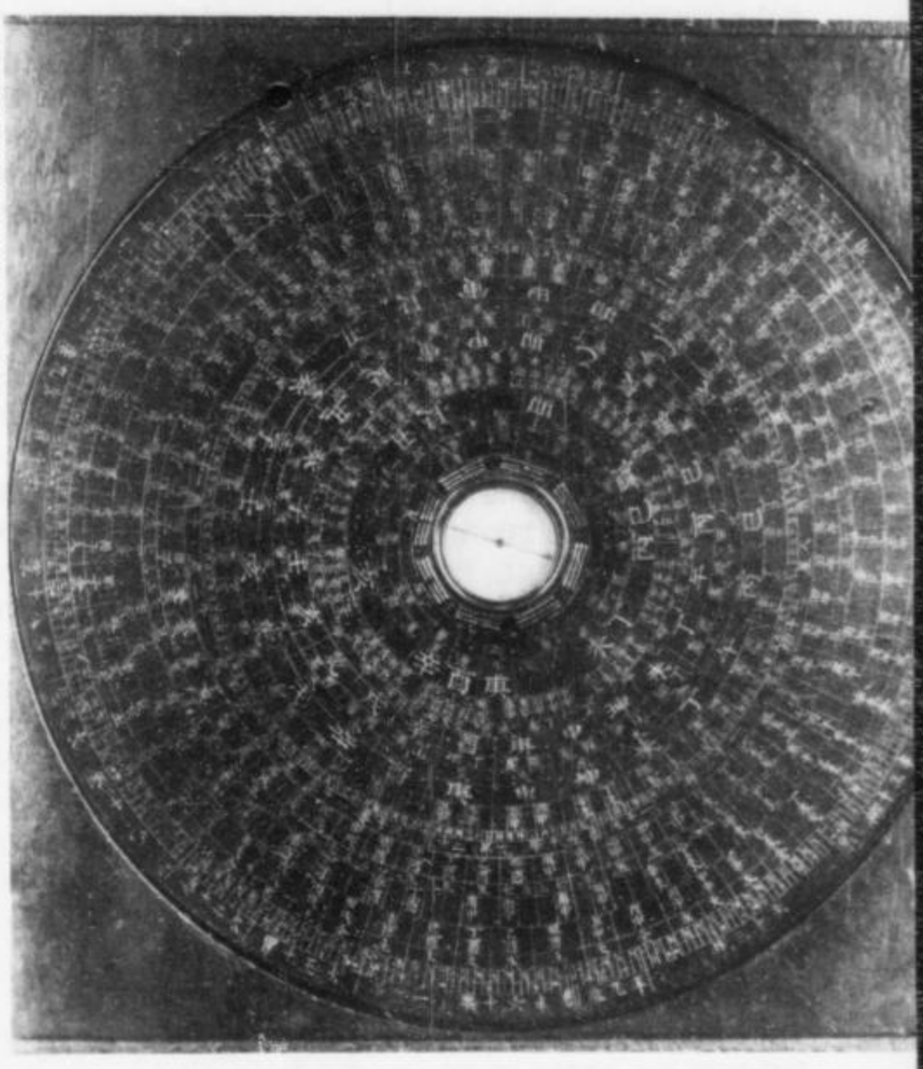


Photo © Science Museum, London

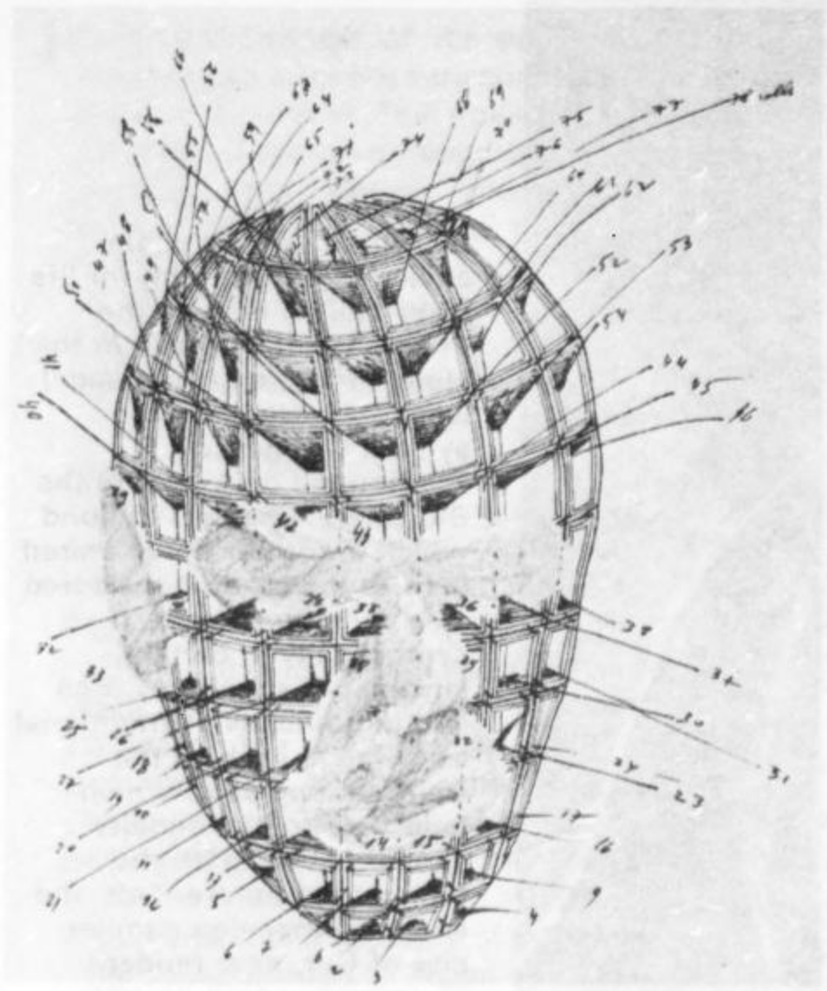


Photo Tom Scott © Scottish National Gallery of Modern Art, Edinburgh

So complex are the situation and interactions with which ecology is concerned that the ideal ecologist, if he existed, would be a kind of superman, his brain stuffed with expertise acquired in the study of a whole range of scientific and social disciplines. Such a man, of course, does not exist, and this is why interdisciplinarity, or team work between groups of scientists each representing a different discipline, has become a prerequisite of modern ecological research. Left, self-portrait by the Romanian artist Paul Neagu.

Perhaps even more serious is the fact that certain scientists allowed themselves to be carried away by the sophistication of the huge computers available to them: some of the ecosystem models seem to have been conceived as ends in themselves rather than as research tools, and the prediction potential of other models is too low. Several fundamental questions have yet to be resolved: to what extent can the results obtained in a given site be extended to ecosystems of the same type in other parts of the world? To what extent can man's intervention in the ecosystem work to his advantage and even increase its productivity? And, when such intervention occurs, what factors ensure the ecosystem's stability?

Moreover, as the IBP drew to its close, it became clear that study of the interactions between ecosystems was just as important as study of those taking place within a given ecosystem. In fact, the most ecologically critical areas are those where two zones meet. The interfaces between different ecosystems, such as, for example, the coastal fringe where land meets sea along the coast and, in tropical regions, the border areas between forest and savannah. Similarly, economic land exploitation systems are not based on a single ecosystem but on exchanges of energy, materials and people between different and complementary ecosystems. Ecology has become increasingly complex, focusing on the study of interfaces (or zones of ecological and cultural interpenetration) and of the various gradations of effects to which ecosystems are subjected by man.

But the main problem for the International Biological Programme was that it had taken place between two major periods. Launched at a time of peak economic growth, it ended in 1974 in a very different period, marked by three major trends. Following the environmental crisis of the early 1970s there was a new awareness of the limited character of natural resources and of the dangers threatening the entire planet; the energy crisis with its economic and social consequences was looming in many countries; and in the developing world there was a growing realization that the gap between it and the industrialized world was widening. In this atmosphere of crisis, politicians and planners turned to the ecologists with urgent questions, but the scientists were unable to provide answers, for, until then, the time factor had not been sufficiently taken into consideration in ecological research.

The developing countries had been made more aware of these problems by the United Nations Conference on the Human Environment, held in Stockholm in June 1972, and were entitled to expect realistic advice from ecologists on the potential use they could make of ecosystems, especially in tropical regions and arid zones. But since the economic and social aspects of these questions had not been considered, ecologists were in no position to provide this advice. Moreover, in the industrialized countries, protest movements had jumped on to the ecology bandwagon and were pressuring governments to reverse the industrial policies of the consumer society, which they considered alienating and dangerous, and to replace them with a new "quality of life".

It is interesting to analyse how professional ecologists reacted when ecology was suddenly catapulted into the public arena as a political platform and a means of pressure. Some were alarmed by the confusion in the use of terms resulting from ecology's newfound popularity and by the fact that ecological concepts had suddenly become commonplace. Certain countries, notably France and Spain, even adopted a new terminology to distinguish between ecology specialists (*écologue, ecólogo*) and political pressure groups or protest movements (*écologistes, ecologistas*). Some specialists in fact joined these movements, taking up the cause of social change with varying degrees of realism or naivety, demagogy or sincere political commitment.

There was nothing really disturbing in the ferment of ideas and the mix of personalities that resulted from all this activity. And, in fact, the ecology movements sometimes succeeded, directly or indirectly, in persuading governments to take greater account of the ecological dimension of development. Indeed, to some extent, it has highlighted the ecologist-scientist's sense of social responsibility. And one can only welcome the trend to regard ecology as "a science for every man and for every day".

We come now to the most recent developments in the history of ecology. It is now recognized that environmental problems affect all countries of the world in varying ways and degrees. It is also generally acknowledged that there are certain problems of a global nature, such as the long distance transport of pollutants, the pollution of oceans, or changes in the atmosphere's ozone layer and concentrations of carbonic gas, which transcend political frontiers. "Only one earth" was the slogan of the Stockholm conference. And, as everyone knows, the phenomenon of life is only possible in the biosphere, a thin layer (very thin on land, much deeper on the oceans) that envelops this planet. The term biosphere, which was coined in 1926 by the Russian scientist V.I. Vernadsky, a pioneer whose work is still amazingly modern in certain of its aspects, indicates ecology's ultimate goal. In the biosphere, man plays a dominant role and consequently his responsibility for its evolution should be the most urgent of our priorities.

It was in this historical and conceptual framework that Unesco's "Man and the Biosphere (MAB) Programme" was launched in November 1971, following a recommendation made at the Biosphere Conference held at Unesco in 1968. MAB

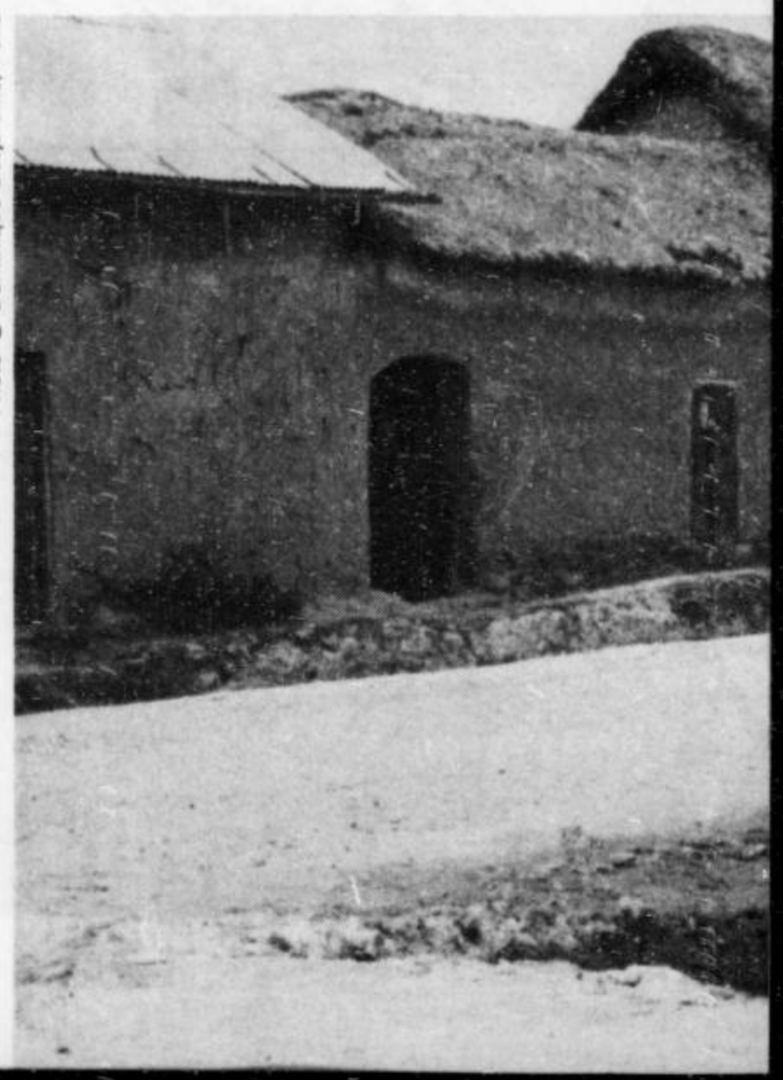


Photo © Dominique Desjardins, Paris

benefited at the outset from the methodology worked out during the International Biological Programme and learned from both its successes and its weaknesses.

The programme soon directed its activities towards action in the field, adopting very simple principles and procedures. The first task was to solve concrete and specific land use planning problems which, in the view of both local planners and scientists, deserved to be given top priority. To solve these very complex problems, interdisciplinary research teams had to be created. Research activities were linked to training, to field demonstrations and environmental education. And, because of the inevitable budgetary constraints that exist in all countries, full use was made of international machinery to co-ordinate national efforts and thus multiply the human and financial resources available. Finally, MAB applied the experimental method of "learning by doing", drawing experience from the successes and failures of field work, and adopted a flexible approach in response to the changing needs and emerging priorities of the various countries.

It is thanks to this adaptability and this experience acquired in the field that MAB has been able to develop its activities so rapidly during its ten years of existence. The programme's point of departure was the study of man from the "outside", i.e. the impact of human activity on the various ecosystems (tropical and temperate forests, savannahs, prairies, tundras, lakes and rivers, mountains and islands). Subsequently, in a growing number of research projects, man came to be considered as an integral part of the ecosystem and of the biosphere, becoming in fact the central element of study.

This changeover from "man the outsider" to "man the insider" is not merely a play on words. It marks a real revolution in concepts and particularly in methods, for ecology has begun to take into consideration the intangible and non-quantifiable elements of human activity and thought—the different perceptions which populations and individuals have of development and of the quality of life, their aspirations and their feelings of belonging and of accomplishment.

The methodological difficulties raised by this new approach are far from being solved. Clearly, many ecologists find it hard to work with data that cannot be quantified and therefore cannot be treated on the same basis as other data. Nevertheless, "participation" has become the key concept in the new generation of MAB activities—participation of the local population at the outset when research priorities are planned, participation of the various disciplines of the natural and human sciences, and participation of decision-makers and planners.

This issue of the *Unesco Courier* presents specific examples of MAB projects in four major priority areas. They illustrate how the very fragile ecosystems of the humid tropics can be used without being destroyed; how the ecological constraints of certain marginal regions (aridity, cold and altitude) can be turned to account in developing these zones; how parts of the biosphere's representative ecosystems can be preserved, not by excluding man from these areas, but by using him, in fact, as the main conservation agent; and, finally, how life can be organized in the urban areas, where the greater part of mankind will be concentrated in the year 2000, by applying a global ecological approach which respects man's dignity and position in the system.

We have now covered the various phases through which ecology has passed, from its beginnings to the present day: descriptive natural history; study of the environment of a single species; study of ecosystems; study of the interactions between ecosystems; study of the biosphere; and study of man in the biosphere. The last phase, "man in the biosphere", is the most "natural" since it completes the evolutionary cycle, reproducing in terms of science what has been man's situation from the very beginning, i.e. an integral part of the biosphere, evolving along with all its other components.

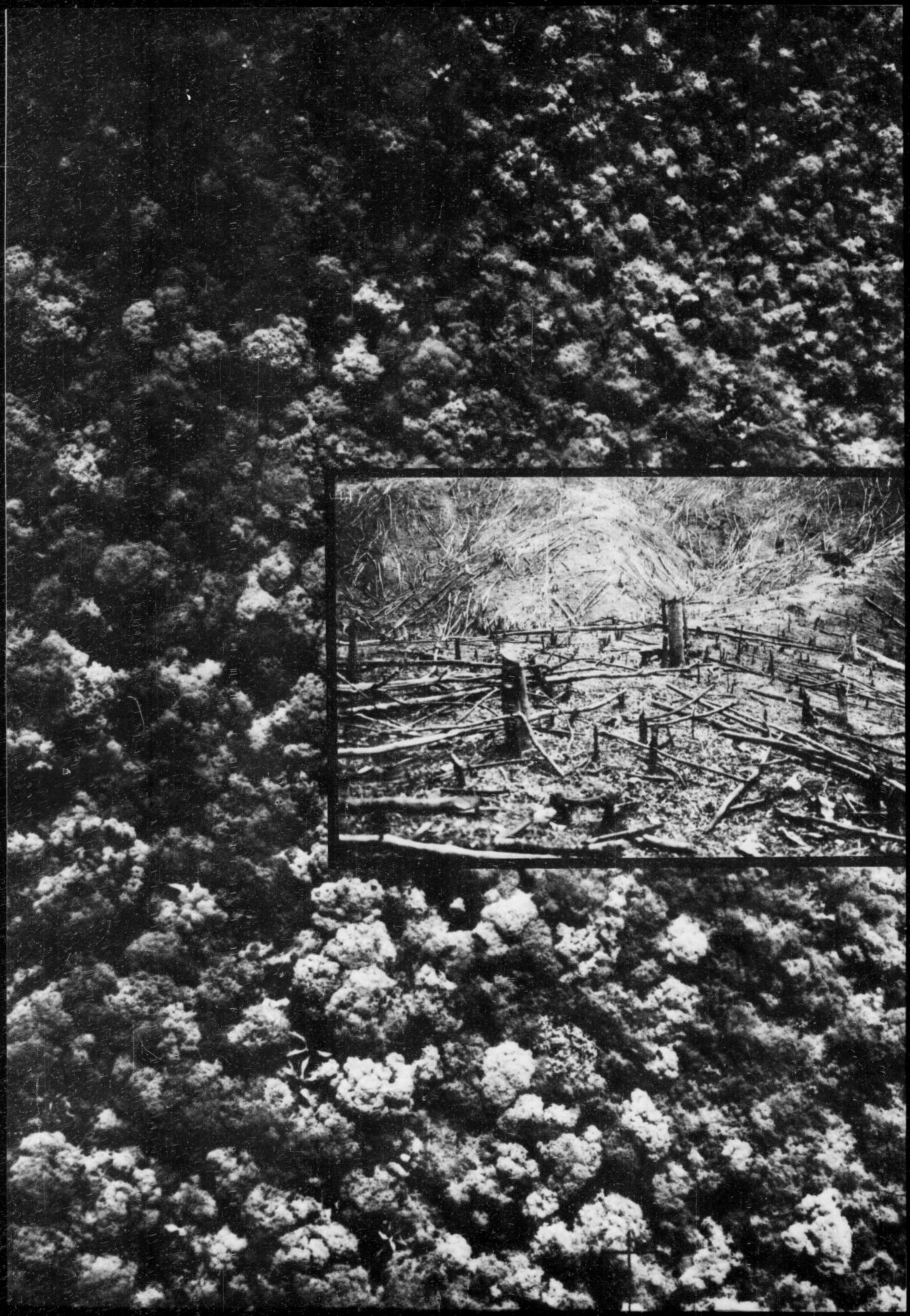
What does the future hold in store for ecology? There is every reason for confidence provided ecology can rid itself of certain weaknesses: it must abandon its jargon without giving way to generalities and over-simplification or departing from scientific rigour; it must prefer action to preaching and learn through action; above all, it must cease to be a negative science (no to pollution, no to deforestation, no to industrial development, no to intensive agriculture) and become a science which provides realistic and specific alternative solutions to the problems of development.

Its strength lies in its capacity to grapple with the real problems of our time, to maintain the flexibility and adaptability that will enable it to face unforseeable situations in the future, to build on participation as an operational basis for helping people to live more harmoniously with one another and with nature. At a time when science in general can claim to be increasingly universal, ecology can affirm its originality by taking as its lodestar the specificity of individual ecosystems and the cultural identity of different peoples.

Is ecology a natural science or a human science? The answer is that it is both, but not a natural science that excludes man, nor a human science isolated from nature. It is a science, but one that can only fulfil its role if those who are engaged in it are deeply aware of their responsibility in the evolution of the human condition.

■ **Francesco di Castri**

"...ecology can affirm its originality by taking as its lodestar the specificity of individual ecosystems and the cultural identity of different peoples". Left, a Bolivian village in the Andes.



The tropical forest, a rich but fragile resource

by Frank Golley and Malcolm Hadley

ALMOST half of the earth's population lives in the tropical forest environment which covers an estimated 2,000 million hectares, mostly in the developing world. The management of these forests is a matter of overriding importance for the countries in which they are situated, for not only do they provide timber for lumber and paper, but their unique diversity of plant life, if wisely harvested, is a renewable source of food, medicines and fuel. Forests also help to regulate the quality and flow of water, an essential factor in development. They are the home of farmers, hunters and gatherers, and yield many products which are both used by these people and sought by city-dwellers.

But forests are also of concern to the world community as a whole. They affect the climate by helping to maintain the earth's temperature and to control the amount of carbon dioxide in the atmosphere. The rare trees and plants of which they consist are a gene pool whose value has only begun to be tapped in the search for drugs to cure some of mankind's worst diseases, including cancer. And so everyone in the world has an interest in making possible the sustained rational use of these forests and woodlands in the humid and sub-humid parts of the tropics.

In the past, the richness of plant and animal species contained in humid tropical ecosystems often led scientists and development planners to incorrect conclusions about the possibilities for development programmes in these zones. Impressed by the mass of vegetation and variety of organisms of the tropical rain forest, far surpassing anything known in forests of the temperate zones, they concluded that the tropics must be very productive.

In some parts of the tropics this is true, in others not. In effect, there are two main sorts of tropical forests; though they may look alike to the outsider or non-specialist, they have very different possibilities for agricultural development. One sort can usually be successfully converted to intensive agricultural crops and tree plantations like rubber and oil palm; these tend to be forests growing on nutrient-rich, generally younger soils developed from alluvial sediments or volcanic ash.

However, forests growing on nutrient-poor, generally older soils, do not have the same potential. Most of the nutrients in these forests are tied-up in the tree biomass, and not in the soil. When the forest is cleared, for large-scale agriculture, most of the nutrients in the system are lost, and yields quickly decline. Hence, the key to the possibilities for development lies in the inherent characteristics of the tropical forests themselves.

The complexity and structural variability of the tropical rain forest are legendary; the German plant geographer Friedrich Humboldt described it over a century ago as "forest piled on forest". Within its depths is to be found a variety of plants, animals and micro-organisms, all ecologically dependent on one another. No other kind of community has so many kinds of plants and animals. A single volcano in the Philippines, for example, has a greater variety of woody plant species growing on its slopes than are found in the entire United States. A two hectare sample of lowland rain forest may contain more than 200 tree species; perhaps ten to twenty tree species would be found in a comparable area in a temperate forest region.

But although well adapted to persist in the relatively predictable environment in which they have evolved, tropical rain forests are less resistant to the disturbances wrought by man than are relatively simple and apparently more robust temperate ecosystems. This fragility led the Mexican biologist Arturo Gomez-Pompa to label the tropical rainforest a "non-renewable resource". Another comment, often heard in scientific and development circles, is that the tropical forest is an overexploited but under-used resource.

Recognition of these special features of tropical forests and the need to guide development has led research workers to seek a better scientific basis on which management can be based. An example within Unesco's Man and the Biosphere (MAB) Programme is a project at San Carlos de Rio Negro in the Amazon region of Venezuela.

It has long been known that the upland soils of the Amazon Basin have a low nutrient content, and, therefore, are not suited to continuous intensive agriculture. What has been less clear is how relatively large forests—with a biomass of about 400 tons per hectare—can maintain themselves more or less indefinitely in the Amazon Basin, despite the low fertility of the soil. The Venezuelan Government is interested in the capacity of these soils to sustain productive forests.

The MAB scientists from Venezuela, the United States and the Federal Republic of Germany, working at San Carlos, have shown that the key to the question of forest productivity is a sophisticated series of nutrient conserving mechanisms of the natural forest.

The forest acts as a sort of massive sponge, absorbing nutrients as they enter the system in the rainfall or from the atmosphere. The well-developed mat of roots, fungi, micro-organisms and humus which occurs on the top of the soil surface appears to be of special significance in the retention and recycling of nutrients within the system. In some places, particularly on mineral soils, this mat can be up to 30 cm thick, and can be peeled back from the soil like a carpet. When leaves or pieces of wood fall and begin to break down, and when rain falls, most of the nutrients that are released or present are not leached away to the underlying soil, but are taken up by root mat and recycled to the living trees.

The efficiency of this root mat in conserving nutrients has been demonstrated at San Carlos through experiments using radioisotopes. Known amounts of radioactively-marked calcium and phosphorus were added to the root mats, and the water which drained through the mats was collected and analysed for radioactivity. Hardly any radioactivity was recorded, even after 6 months following the application of radioactive materials. Over 99 per cent of the tagged nutrients were absorbed by the root mat, indicating that practically all the dissolved nutrients from decomposing organic material or from rainfall move directly into roots without passing into the mineral soil. The root mat of an undisturbed forest therefore prevents the loss of nutrients from the system.

The critical point about nutrient conserving mechanisms like these is that they are part of the living organic structure of the undisturbed forest, which is destroyed when the forests are cleared, for agriculture. This explains why the productivity of these systems quickly falls away when the forest is removed.

But the problems of development and conservation of the ecosystems of the humid tropics calls for scientific research not just on plants, animals, micro-organisms and soil. Man is also a part of the forest system, an overwhelming part in many regions, both as an agent of change and as an entity affected by change.

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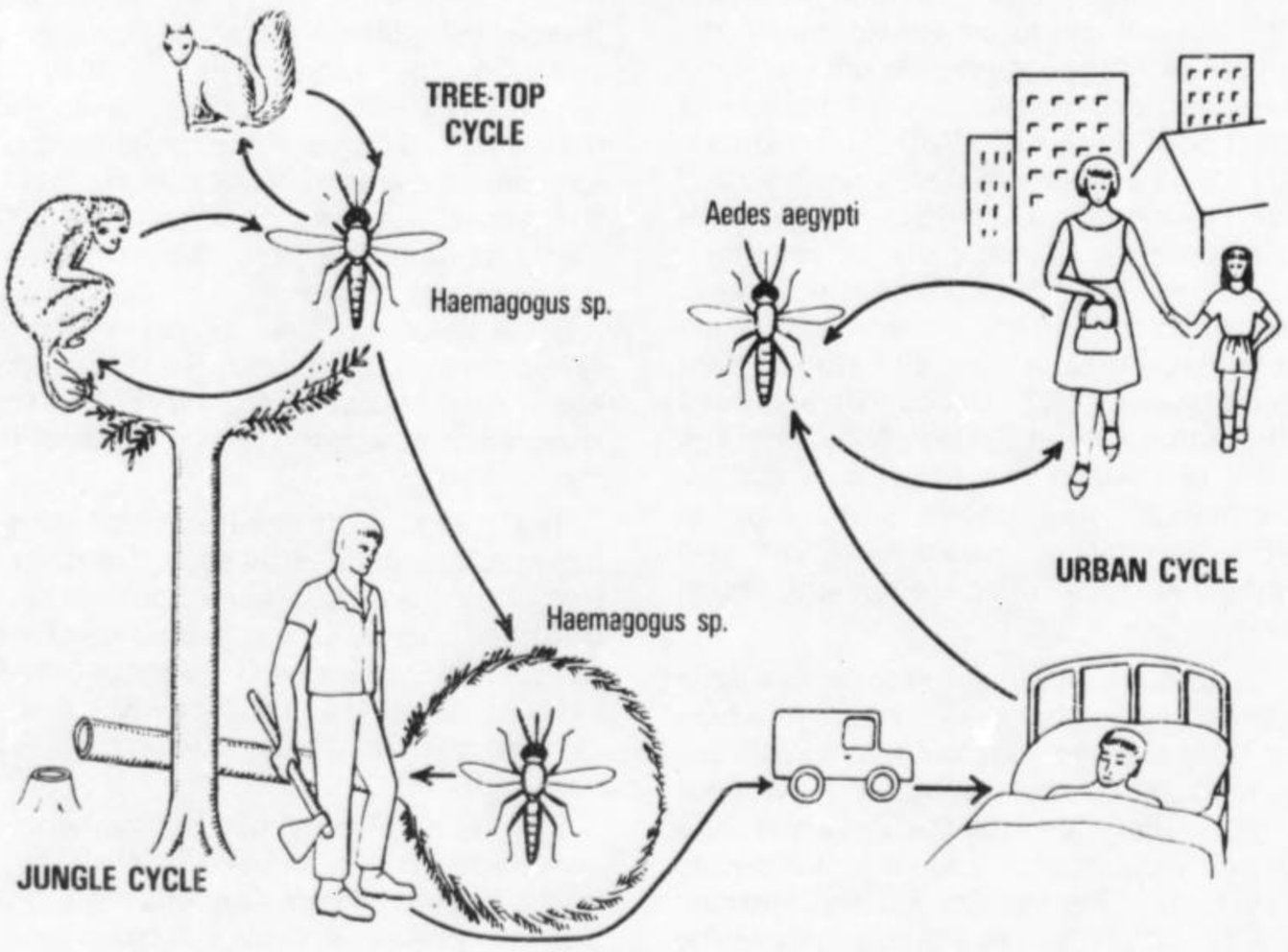
MALCOLM HADLEY *is a staff member of Unesco's Division of Ecological Sciences. A zoologist, he is responsible for the co-ordination of activities in the humid tropics within Unesco's Man and the Biosphere (MAB) Programme.*

Photo MAB, Unesco

Photo M. Hadley, Unesco

Traditionally, many peoples of the humid tropics practice "swidden" or "shift and burn" cultivation. A small area of forest is cut and burned and the land thus cleared is cultivated for one or two crop cycles. The area is then left fallow for ten or more years to allow the vegetation to build up its stock of nutrients ready for another short burst of cultivation. Provided the fallow period is long enough, shifting cultivation is a perfectly sound system of land use in poor soil areas which cannot support more intensive use. Above, an area of forest in East Kalimantan, Indonesia, being cleared by burning. Left, two young Indonesians carry cassava, a crop often grown on swidden clearings.



A tropical forest ecosystem is the habitat of a multitude of animals including thousands of insect species. Many of them form communities that are mainly restricted to a particular layer of the forest, some to the jungle floor, for example, and others to the tree-tops. Some of these creatures are reservoirs or vectors of diseases that can be passed on to man. Thus, in the tropical forests of central and South America, monkeys and marmosets inhabiting principally the tree-top layer of the forest form a reservoir of yellow fever. The virus is spread between them by blood-sucking mosquitoes such as the *Haemagogus* species. Tree-felling exposes man to the bites of these virus-carrying mosquitoes and infected forest workers then carry the virus to villages and towns where it is further disseminated by other mosquitoes such as the *Aedes aegypti* species.

Drawing from J.I. Cooper and T.W. Tinsley, Transactions of the International MAB-IUFRO Workshop on Tropical Rainforest Ecosystems Research, 1977, Hamburg-Reinbek

This process of change is taking place in regions which have a long and rich history of human activity, as witness the ancient forest cultures of the Mayas, the people of Angkor Wat and the Benin of Nigeria.

In several parts of South-East Asia, South and Central America and West and Central Africa, forests were long ago successfully transformed into rice paddies and other types of productive agricultural land. The transformation has been particularly successful in areas with nutrient-rich soils which for centuries have supported dense human populations, in such areas as Java and the Mekong Delta.

However, the intensity of human activity currently taking place and the consequent ecological impacts are unique in history. Forests are being cleared or altered at an unprecedented rate. Although scientists are not certain how fast tropical forest lands are being cleared or severely altered, estimates range from one to two per cent of the existing area per year. Unless the present trend is halted, all the primary lowland tropical rain forest in the world may disappear well before the end of the century (except in inaccessible sites and a few small biological reserves).

The major causes of tropical forest depletion are rapid population growth in tropical countries and the need for agricultural land to produce food for these multitudes; resource development to achieve economic growth; the accelerated search for new wood supplies by developed temperate region countries; and the overcutting of forests as a source of fuelwood for heating and cooking.

Commercial logging and transmigration are having a major impact on the tropical rain forests of Asia. A MAB research team co-ordinated by the Indonesian Institute of Sciences (LIPI), has been looking at the interactions between these human activities and tropical forest ecosystems in the Indonesian province of East Kalimantan. East Kalimantan is a large, economically booming province on the island of Borneo. It covers a territory of 21 million hectares, an area about twice the size of Iceland, with a population of only 1 million people. About 17 million hectares, over three-quarters of the province, are forested. The area represents an immense reserve of timber, much of it valuable hardwoods, as well as a place for resettling people from the densely populated islands of Indonesia such as Java and Bali.

Quite naturally, the central government has considered East Kalimantan to be a prime economic asset, which should and must contribute to the national development goals. Today, there are more than 100 licensed logging companies busily at work extracting timber from the 13 million hectares earmarked for selective logging. Selective in this case means the cutting of up to 20 trees per hectare, according to botanist Dr. Kuswata Kartawinata, leader of the MAB research effort in East Kalimantan and Head of the Bogor Herbarium of Indonesia's National Biological Institute.

Unfortunately, during the removal of selected logs, 41 per cent of the remaining trees have been shown to be damaged. Furthermore, current selective logging practice results in the creaming off of the best trees of the commercial species, leaving only undesirable, smaller trees in the residual stands to provide seeds for the next crop

The taming of a swamp

The 'Chinampa' project—Mexico

The Problem: to find inexpensive ways of increasing food output using systems of production that take advantage of the special characteristics of the tropical forest environment, that can be sustained indefinitely without the need for large scale additional resources (such as fertilizers) from outside.

The Project: links scientific understanding of an age-old, traditional agricultural system with the need for increased food production in humid tropical zones of Mexico. The chinampa is a low-capital, self-sufficient agricultural system which was used by pre-Columbian peoples throughout tropical America and is still practised in Mexico Valley.

The system consists of creating small plots of land on which crops can be grown from plant materials and mud dredged up from the bottom of swamps and lakes, the plots being separated from each other by water channels in which fish can be raised. The word chinampa means "net of branches" and it was probably on mats of branches and leaves that the early cultivators first built their chinampa fields.

A diversity of crops can be grown on these small "artificial" plots and production is unusually high and predictable. By its very nature, the chinampa is a labour-intensive method of agriculture since the farmer must constantly maintain the height of the plots and keep the water channels open. But this can be a positive advantage in many tropical countries where the supply of labour outstrips the demand.

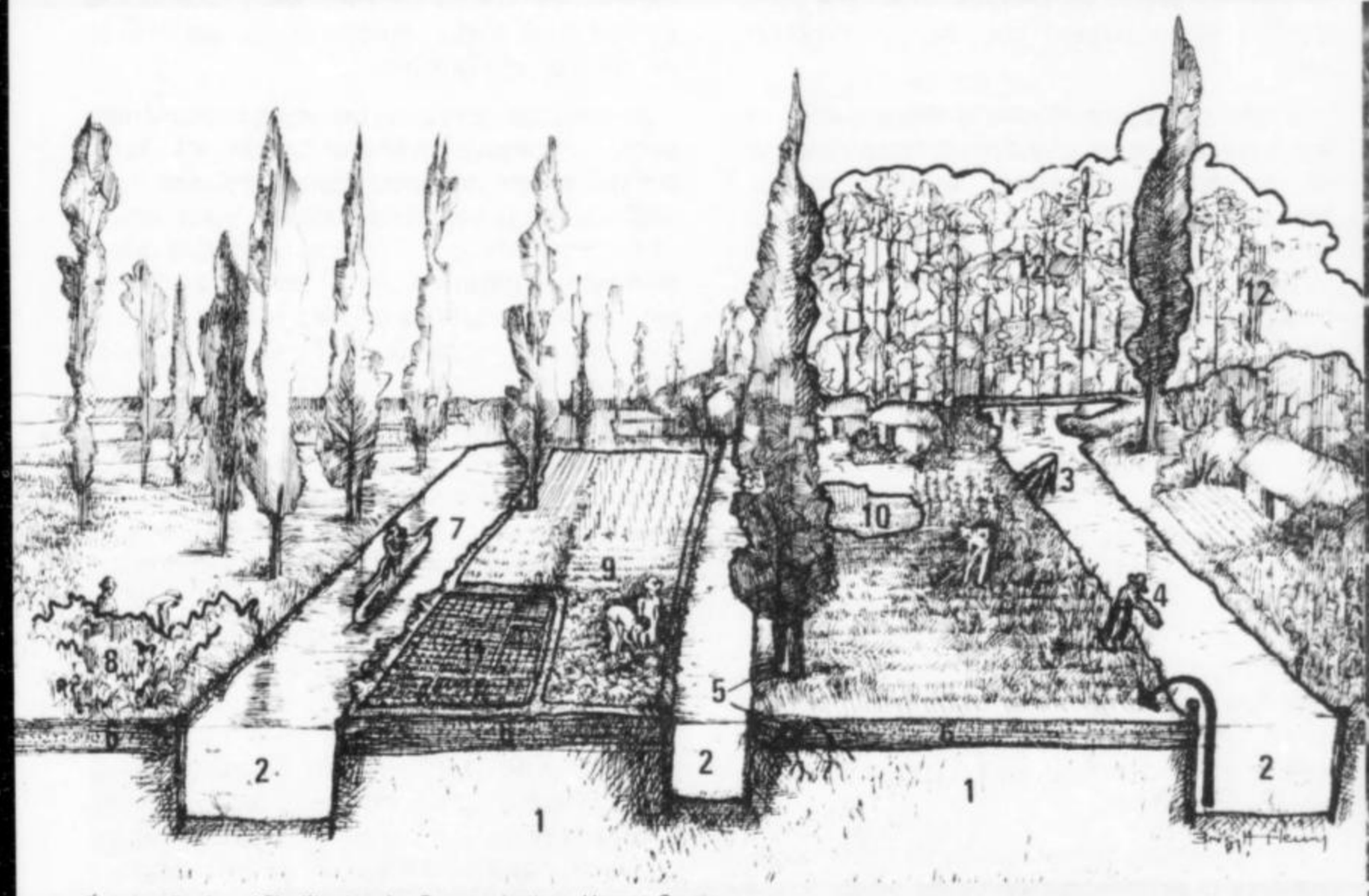
A group of Mexican MAB scientists recognized the special nature and the success of the chinampa method and decided to experiment with it in order to create a new method of meeting food needs. The research team was made up of some fourteen scientists including specialists in agronomy, biology, anthropology, sociology, economics and pisciculture, based at the Institute for the Study of Biological Resources (INIREB) at Jalapa.

They selected four rain forest areas in Mexico. One of these areas, in Tabasco State, consisted of a combination of semi-evergreen rain forest and swamps where the human population could benefit from increased food production. Another, very different, site was chosen in tropical rain forest at Chiapas where shifting cultivation is widely used. Here chinampas were built near a river which provided the irrigation water. The organic mulch for the chinampa plots was obtained from the litter (the fallen, decomposed débris of leaves and branches) of the adjacent rain forest.

The Results: within a few months after chinampa construction, a variety of crops were growing, including beans, corn, spinach and other vegetables. A crop of over 54 tons per hectare of celery was achieved within a period of 150 days.

In 1976, the scientists handed over the experimental site to local farmers who not only continued to cultivate it along chinampa lines but have since enlarged it using their own resources.

Here then, a team of natural and social scientists working with the local populations, have studied and interpreted a traditional, local technology and then successfully translated it into modern terms and transferred it to a new location. This is a case of transfer of technology within the same ecological region and not, like many examples where transfer has failed, from temperate to tropical regions. The MAB project has thus demonstrated that in the Mexican chinampa there exists an ancient and ecologically sound system of agriculture that could be applied elsewhere in tropical lands, particularly in areas where water is plentiful.



Drawing *Etudes et Planification des Communications,* Unesco Courier

Photo MAB/Unesco

Drawing, above, shows how the *chinampa* system works. Small raised plots of land are constructed (1) and separated by a network of water channels (2), which are used for transportation as well as providing a ready source of fish (3) and of water for irrigation (4). Trees and stakes (5) hold the sides of the *chinampas* firmly in place. The soil of the plot is constantly replenished with organic débris (plant and animal), aquatic plants and mud (6). The *chinamperos* scoop up fresh mud from the bottom of the channels and load it into their boats (7). They spread the mud on the *chinampa* plot before planting a new crop, thus helping to maintain its fertility. A wide variety of crops is grown including maize (8), beans (9), and green vegetables (10). The seed nursery (11) is an essential element of *chinampa* farming; seeds are sown in small mud cubes, called *chapines,* which are transplanted once the seedlings are established. The adjacent tropical forest (12) is a source of many other products used by the *chinamperos.* Above right, a typical *chinampa* plot in Mexico.

Nature's chemical factory

There are over one hundred different chemical elements in the world, arranged in an infinite number of combinations. If you were to write a formula for a tree, you would find you had so many carbons per gramme, so many calciums, so many zincs, so many leads, and so on.

Now that chemical formula has developed through a long process, starting with the chemical environment in which the tree first evolved. If the tree originated in a very calcium-rich environment, it would have lots of calcium in its original formula.

But in the course of its long evolution the tree has moved about over the surface of the earth. In its travels it has encountered whole new environments and lots of other species, so its chemistry is constantly evolving. The chemical formula of a tree is, as it were, the signature of the species to which it belongs. If you go into a forest and study the chemistry of each species you will find that they differ from one another in fascinating ways.

Scientists working on the MAB project in San Carlos, Venezuela, have been testing the effect of location on the chemistry of trees. They have compared trees which are of different species but whose roots have the same soil area with individuals of the same species whose roots share different soil areas. And they found that for the essential elements individual trees of the same species have the same chemistry—the signatures are the same.

Tropical forests have long been known as a rich source of natural products. Some trees, like sandalwood, have an aromatic nature and their oils have been collected for thousands of years. Some have a beautiful patina when they are cut, like teak and mahogany. Some produce materials that have medical value, like quinine. Other products of tropical forest trees, like rubber, palm-oil and cocoa have long played an important role in the world economy.

But a tree that produces rubber might have very many other interesting chemical characteristics that have never been explored. Literally thousands of chemicals are produced in trees, in some cases in large quantities. Indeed, trees are like factories in that they provide major products, sub-products and waste products. If we adopt this industrial analogy we begin to get a glimpse of the tremendous benefits that could result from better understanding of forest chemistry.

The tropical forest represents a virtually untapped reservoir of new chemical compounds. Many show potential as medicines; a tropical periwinkle plant, for example, is providing a chemical used to fight leukaemia. One Brazilian tree holds promise as a source of oil that can be used directly to power automobiles.

But the search for new chemical products has only just begun. Less that a tenth of the estimated 150,000 species of tropical flowering trees has been screened for even a single class of chemical compounds. It can reasonably be expected that the remaining plants will ultimately provide numerous new compounds that will prove useful in medicine and as sources of industrial products such as gums, latex, resins, dyes, waxes, oils and sweeteners, as well as new sources of energy.

The opportunity is there for imaginative research. But it is a fleeting opportunity, for, with our overriding concern to achieve immediate, short-term benefits and our concentration on the creation of simplified agricultural systems, we are condemning many as yet unexamined species to extinction.

and this may result in an inferior forest for future use.

Transmigration of people from densely populated parts of Indonesia is another major agent of change in East Kalimantan. Accustomed to intensive farming on rich volcanic soils in Java or Bali which can produce two or three crops of rice each year, the newcomers often found themselves allocated plots of land too infertile and too small to provide an adequate livelihood. Many of these people supplement their living by harvesting the resources of the forests, particularly the valuable Borneo ironwood tree. Thus, the transplanted people not only have an impact on the areas of former forest cleared for agriculture but also the intact forest reserved for other uses.

Taking part in the MAB project in East Kalimantan are a group of American human ecologists. With their Indonesian colleagues, they are looking at questions relevant to policy-making of the interactions between people and forests in the province. Their initial results show that the people of East Kalimantan are highly responsive to changing economic opportunity. This is demonstrated by some of the activities and processes looked at by the MAB team. For example, the spontaneous migration of thousands of Bugis farmers from the island of Sulawesi in order to convert East Kalimantan forest land into plantations of pepper, a crop the people had not grown in their homeland; the movement of Dayaks from the interior plateau of Borneo to lowland areas where they have eagerly taken to using chain-saws and *perahu* (canoes) with outboard motors in their activities as shifting cultivators; the greatly increased allocation of time and effort to the collection of incense wood by Dayaks when the price traders were paying for that commodity rose.

These examples illustrate the capacity of local peoples and governments to respond to a rapidly changing modern world. However, their ability to change systems of forestry, agriculture and governmental services to conserve their natural resource base, their special natural heritage, and provide for their needs over an indefinite future depends upon knowledge applied in culturally sound ways.

In this modern age of rapid communications, the topic of forest transformation has aroused interest in many parts of the world—not just in the tropical countries themselves. Different perspectives and perceptions have emerged, and it must be recognized that a number of tropical countries have felt uncomfortable about the attention that has been given to tropical forests by individuals and groups in non-tropical countries.

For example, there has been much controversy over the last ten years or so about the possible consequences of large scale vegetation clearance in the Amazonian Basin. Some scientists and government officials, mainly from non-tropical countries, have argued that the destruction of these forests could bring, among other consequences, changes in the composition of the atmosphere, changes in patterns of rains within and outside the Basin and disappearance of animal and plant species whose potential usefulness for man are unknown.

On the other hand, tropical countries, such as Brazil, have defended the right to exploit and utilize for their own benefit the potential of these regions in the same way as developed countries.

In middle latitude European countries, such wholesale transformation of temperate forests occurred many centuries ago, and no-one recognized serious deterioration of the environment. Tropical countries question why a different set of criteria and considerations should be applied now to them in the era of change of their national ecosystems.

Whatever one's views on this question, it seems clear that interest in, and concern for, resource development in the humid tropics will continue to increase in the present decade. From the scientific and technical viewpoint, it can be said that transformation and development of the tropical forests can be economically successful and ecologically sound if done in the right place and in the right way. But great damage will be done, and is being done, when transformation takes place in the wrong places or in the wrong ways. The object of research is to guide development into sound pathways.

MAB research is aimed at providing new information about man and natural forests, derived from field research guided by local people and their decision-makers, in a form that can be understood and quickly put to work. In this endeavour, scientists from all countries can co-operate. The success of MAB projects in several tropical forest areas makes one optimistic that the approach is viable and that change can be positive.

■ **Frank Golley and Malcolm Hadley**

The changing forest

The Tai project—Ivory Coast

The Problem: to provide a better scientific basis for managing tropical forests, linking measures for conservation with the needs of economic development.

The Project: is focussed on the south-west Ivory Coast, an area of tropical forest which until recently was largely uninhabited. The late 1960s and 1970s heralded an enormous growth in the population of the region. In 1965, the Ivory Coast Government decided to bring the forest area into the national economy. Wide-ranging development projects were started, including the construction of San Pedro port and town, a hydro-electric scheme and paper-pulp mill, together with a railway and various agro-industrial complexes, such as oil and coco-palm plantations.

The south-west Ivory Coast is therefore an area of rapid change. It represents a sort of microcosm of changes, opportunities and problems that are occurring in many parts of the humid and sub-humid tropics. It is also an area where scientific research can precede or accompany and thus help to shape the form of economic development. This opportunity, seldom encountered, led to the setting up of the MAB Tai Forest project in 1973, by the Ivory Coast Ministry of Scientific Research. The project takes its name from the Tai Forest, the largest (300,000 hectares) intact area of tropical rain forest in West Africa.

The MAB project is built around eight research programmes, co-ordinated by the University Institute of Tropical Ecology in Abidjan and involving scientists from a number of disciplines and countries. Participating institutions include the National Institutes of Ethnosociology and of Meteorology in the Ivory Coast, the Office of Overseas Scientific and Technical Research of France, the Mycology Laboratory of the University of Rome. A substantial facility for field research and training has been set up at Tai.

The Results: in contrast to most temperate regions, basic data on the local environment is lacking in many parts of the tropics. The first task therefore was to carry out surveys of soils, vegetation, insects, large vertebrates, human populations, etc. A team of anthropologists and geographers undertook a study of the impact of a pioneer front of immigrant farmers on the local people. The immigrants came from the north in the 1960s and 1970s, to take advantage of new economic opportunities presented by the opening-up of forest areas in the south-west Ivory Coast. At first, the indigenous people adopted a favourable attitude towards the immigrants, and gave them free access to their lands.

The newcomers arrived in ever increasing numbers and, showing considerable initiative with their cash crops (coffee, cocoa), and intensive land use practices, began to dominate the local economy, previously based on shift-and-burn cultivation.

Research by the MAB team documented the factors which enabled the pioneer front to establish itself and highlighted the conflicts between a new land use strategy and a traditional one. At the end of the study, recommendations were made to the government concerning the possible consequences of, and reactions to, the expansion or establishment of new fronts of pioneer farmers.

Below, a water and soil erosion monitoring station in the Tai forest. Installations such as this enable scientists to measure the water draining away and the soil carried with it from sections of forest that have been cleared and cultivated by man as compared with the natural water run-off and soil erosion from intact forest areas.

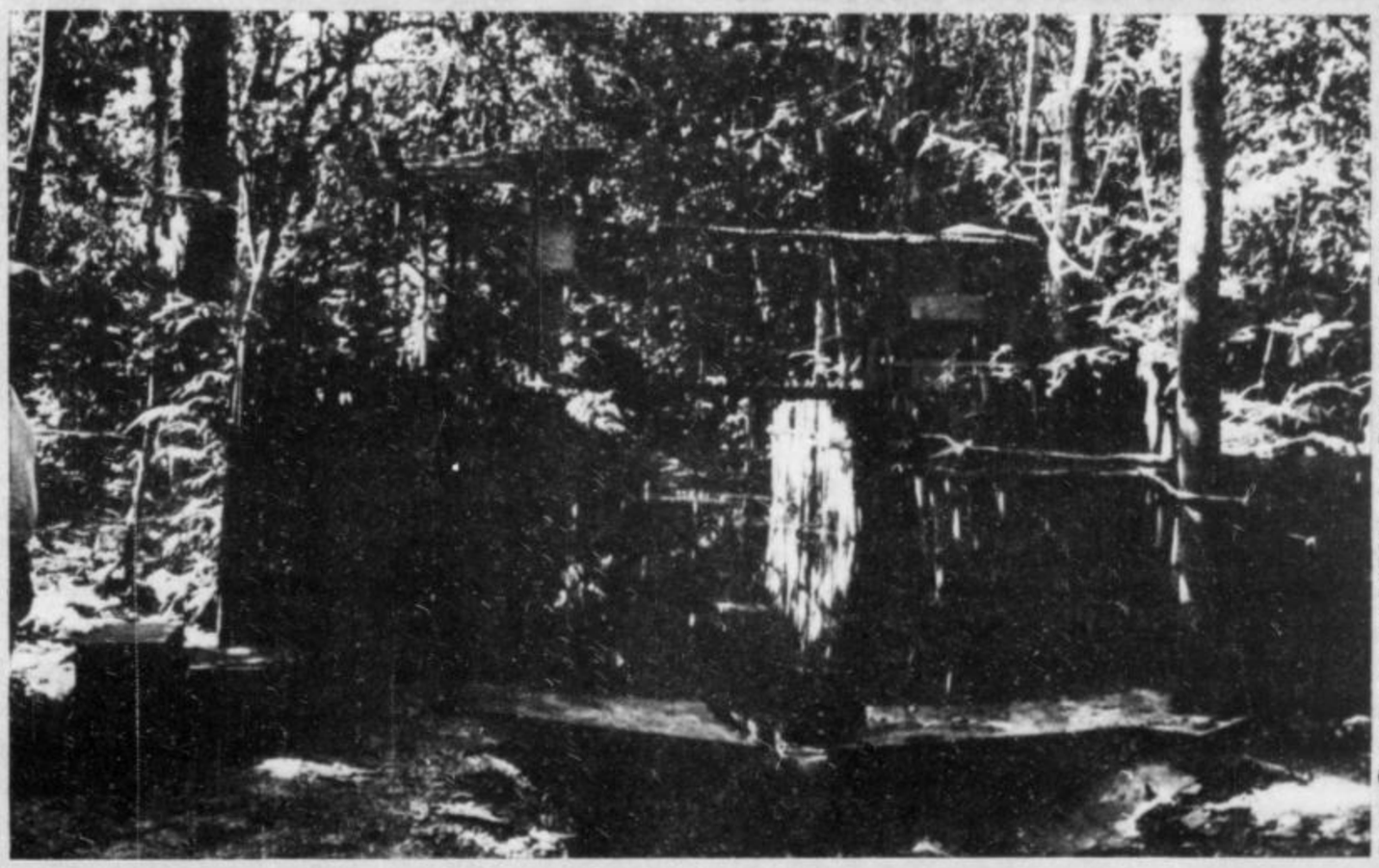


Photo © A. Beaudou, ORSTOM, Adio Padoum, Ivory Coast

Botanists at Tai have been looking at the role of a different kind of pioneer—a group of sun-loving shrubs and small trees with a short life span, which appear in the forest following more or less extensive disturbance.

The primary forest trees are relatively slow growing. Their seeds are not plentiful and they require shade and moisture for germination. Thus, these trees are not able to re-establish themselves on land that has been abandoned following clearance and cultivation. The so-called pioneer species of shrubs and small trees, however, have a characteristic, rapidly growing root system. Full root potential is quickly achieved through rapid occupation of the upper soil layers.

One reason for the success of the pioneer plants seems to be their habit of feeding off each other. After about 3 years, root grafts appear between individual plants. Using radio-active substances the Tai botanists have shown that some individual trees "feed off" and drain the root system of their neighbours, and eventually take over the living part of the root system after the death of the neighbours.

The importance of these pioneer species is that they create the moist, shady conditions which enable the primary forest trees to regenerate themselves. They are therefore an essential element in the reconstitution of the original forest after a period of clearance and cultivation.

The first results obtained by the soil scientists working on the Tai project show that forest clearance followed by burning results in a considerable reduction in the overall activity of the soil. However, the soil rapidly regains its former levels of organic matter content, and other principal characteristics.

The significance of these results is that it should be possible to shorten present fallow periods, once the difficulties involved in clearing dense vegetation, and in countering certain animal pests and parasites have been surmounted.

The Tai soil scientists also studied changes in the rate of erosion under different land uses. Rather surprisingly, low rates of erosion were recorded under traditional shift-and-burn agriculture; these rates were comparable to those recorded within the intact forest. However, it was thought likely that when larger areas were cleared for cultivation, erosion rates would rise considerably.

A somewhat startling aspect of the MAB project is what might be described as a "gaseous" study. One hardly expects to find a forest generating gases usually thought of as pollutants—gases like sulphur dioxide and other sulphur derivatives. But levels of airborne sulphur have been recorded in Ivory Coast forests that are higher than in agricultural areas of France and are comparable with those experienced in large industrial towns. The clue to their origin lies in the decomposition of organic material in the forest ecosystems under conditions of low oxygen content.

Yet it should be borne in mind that such "noxious" gases contribute to the overall composition of the earth's atmosphere and for mankind it is vital to know the extent to which changes in tropical forests are affecting the delicate balance of that atmosphere. The Tai Forest project shows how an in-depth study of a tropical forest such as that undertaken by the MAB scientists can reveal data of importance to the sum total of world studies.

Marginal lands

Inhospitable 'fringe' regions ingeniously turned to human advantage

by Mohamed Ayyad and Gisbert Glaser

ALTHOUGH we refer to the whole planet as our habitat, the land surface on which we live constitutes only about a quarter of the total surface of the globe, and of this less than a quarter is well populated and intensively used. A large part of the remainder is made up of desert, ice cap and mountain peaks.

Between these two extremes lie the marginal lands, areas subject to certain natural constraints which limit the possibility of intensive cultivation with high crop yields and which, if they attain a certain threshold, make cultivation impossible.

These constraints fall into three main categories: irregular rainfall and lack of water (the arid and semi-arid zones); extremes of cold (high elevations in mountain areas and the sub-polar tundra regions in both the northern and southern hemispheres); and steepness of slope (mountain areas everywhere).

Surprisingly enough, despite the great difficulties involved, close on eight hundred million people (though this is a very approximate estimate) inhabit these marginal lands, showing great ingenuity in adapting to the constraints they impose and even, in some cases, turning them to their advantage.

Before the development of modern transportation, for example, the true deserts, such as the Sahara and the high summits of the mountain chains, constituted barriers between areas of intensive human activity which could be likened to the barrier of the seas. The people living at the boundaries of the deserts and below the passes crossing the high mountains were quick to take advantage of this situation. To supplement the meagre living they obtained from the land they assumed the function of the seafarer, transporting goods and people across the desert and mountain passes.

Nowadays the camel caravans have almost disappeared from the Sahara and other deserts and the high mountain farmers no longer keep horses and mules for transport purposes.

But the resourcefulness of the inhabitants of these regions remains. The major constraints of the Alps—snow, ice, cold and steep slopes—have been used to form the basis of a highly profitable industry, winter tourism, and the high number of sunny, rainless days that make agricultural activity so difficult in North Africa now attract tens of thousands of sun-loving tourists every year.

Ingenuity on the part of the farmers of the Nochixtlan Valley in southern Mexico in overcoming a rather different kind of constraint has been revealed in a recent Man and the Biosphere (MAB) publication. The side slopes of the Valley are ravaged by active gully erosion, a process which strips off the surface soil leaving the slopes barren and bare of vegetation. What a terrible constraint for agriculture !

Yet the farmers of the Valley took advantage of this erosion and made a resource out of it. Over the past thousand years, by directing the flow of eroded material from the side slopes, these Mixtec cultivators have doubled the cultivatable area of the main valley floors and have filled in the narrow tributary valley floors with flights of terraces several kilometres long. Before large-scale erosion began the agricultural productivity of the valley area was certainly much lower than it is today.

The high culture of the Incas in the Andes is an outstanding example, on a much larger scale, of adaptation to natural constraints. One might have expected the Incas to concentrate in the coastal and lowland areas, but their preferred environment was the healthier high mountain, the altiplanos, at altitudes ranging from 2,800 to 4,000 metres, and the large valley systems of the central and northern Andes.

Here they created an area of relatively dense population and evolved one of the most remarkable pre-Columbian cultures in the New World. They coped in masterly fashion with the constraints of cold on the altiplanos and the steepness of the slopes of the valleys. On the slopes they developed a very efficient terracing system; on the altiplanos they combined llama and alpaca herding with limited agriculture specifically adapted to the cold and the reduced oxygen available. The fact that the potato, which was to become a staple food over much of northern Europe in later centuries, originated from the "marginal lands" of the Incas provides some measure of the success of their system.

Although essentially based on the altiplanos, the Incas nevertheless made use of the opportunities offered by variations in altitude, including in their landholdings some areas with a hot and humid tropical climate in the low-lying foothills of the eastern escarpments of the Andes as well as areas of temperate climate at altitudes of 1,500 to 2,500 metres. Thus their economy provided for tropical fruit and bananas, cotton and maize from the more temperate altitude levels as well as grain, potatoes and animal products from the colder high altitude levels.

Photo Hans Silvester © Rapho, Paris

A comparatively simple example of a quite different strategy adopted in other marginal lands is the transhumance system in France whereby the sheep and goats graze in the Alps during the summer and in the Mediterranean maquis or the Camargues during the winter. In this way the problem is solved of how to cope with two constraints, namely to feed the herds when the Alps are covered with snow and when Mediterranean France experiences its summer drought.

On a very much larger scale, transhumance in the arid and semi-arid zones of Africa takes advantage not of opposing constraints (such as extremes of cold and drought in the example from France above),

but of variations in the rigour of the same constraint—aridity.

In the past, the traditional nomads roamed with their herds and their families over hundreds of kilometres in order to make available to their cattle the fresh grasses and shrubs that sprang up after the rare days of rainfall even in the most arid and remote areas. Today the tendency is more and more for the herdsmen's families to adopt the sedentary way of life, settling in villages, while the herdsmen themselves move their flocks between three complementary grazing zones south of the Sahara.

These zones consist of the so-called Sudanese zone, which has about six or seven dry months, the Sahelian or semi-arid zone, with eight or nine dry months, and finally the fringes of the Sahara, with ten to eleven dry months. A system is developing whereby the Sudanese zone, which has a strong agricultural element, is beginning also to specialize in the rearing of young livestock and the final fattening up of cattle before they are taken to slaughterhouses for sale in the major markets in the coastal zones. The Sahelian zone, where the nomads are beginning to settle, is devoted to the reproduction phase, and the fringes of the desert are only grazed for a few months after the rare rainy spells in this area to relieve grazing pressure on the Sahelian zone.

Mankind has, then, often been very successful in overcoming the varied disadvantages and constraints that affect marginal lands, particularly in making use of them for grazing. Few people realize, for example, that the arid and semi-arid zones as a whole support over half the world's stock of cattle,

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Photo F. Mattioli © FAO, Rome

In northern Kenya, one important cause of desert encroachment is the felling of trees and shrubs by nomadic herdsmen to make *bomas,* or night enclosures, to keep their livestock from straying and to protect them from wild animals such as jackals, hyenas, leopards and lions that hunt at night. The herdsmen move several times a year and for every move trees are cut and new *bomas* are built. Scientists in MAB's Integrated Project on Arid Lands (IPAL) have found that, for the *bomas* of the Gabra people, about twelve Acacia trees are used per household per move, or 70 to 100 trees per household per year. Below, a typical settlement of the Rendille people with its thin outer thorn fence surrounding the circle of family dwellings with the livestock enclosures in the centre. Separate enclosures are used for camels and for sheep and goats. Sponsored by the Kenyan National Committee for MAB and executed by Unesco, IPAL is designed to provide a better scientific basis for land management in arid lands. The project was financed mainly by the United Nations Environment Programme from 1976 to 1980, when funding was taken over by the Federal Republic of Germany. Deforestation is contributing to the spread of deserts throughout the arid and semi-arid regions of Africa where wood is virtually the sole fuel available for cooking and heating. Above, these women of Mali often have to walk many kilometres every day to gather firewood.

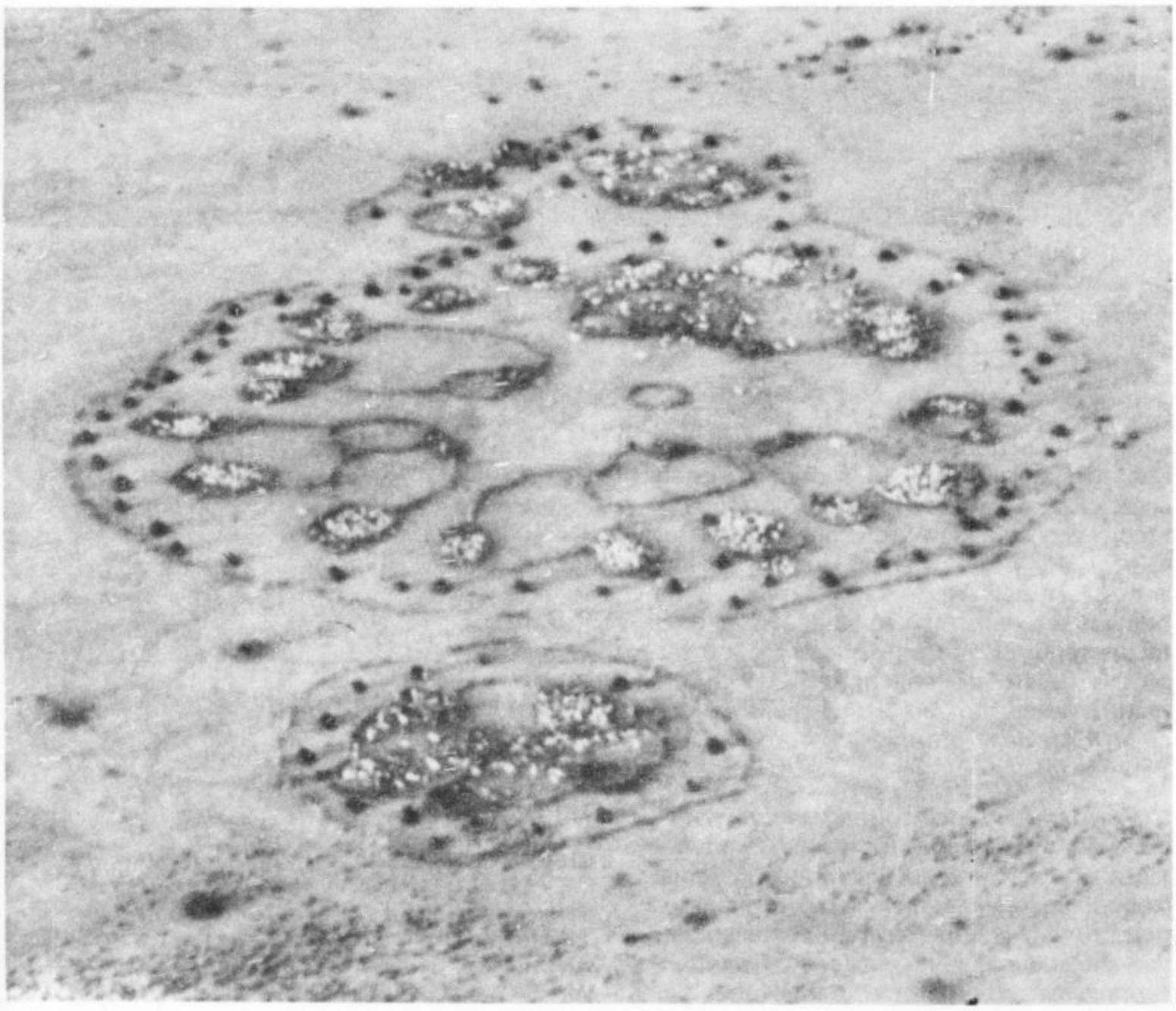


Photo © S. Schwartz

more than a third of its sheep and two-thirds of its goats.

As the examples given above indicate, one of the keys to these successes lies in the application of the notion of complementarity: that is, the combined use of two or more zones in such a way that their respective constraints offset or complement each other. This may involve zones of different altitudes (as in the case of the altiplanos and the foothills of the Andes), or zones of varying aridity (as in Africa south of the Sahara), or zones of different socio-economic nature (were it not for densely populated, highly industrialized lowlands that surround them, the European Alps would never have experienced the astonishing development of winter sports and summer tourism that has occurred in recent years).

So far, however, the most important constraint of all and one which affects all marginal lands has not been mentioned—their fragility.

Landscapes, vegetation and soil cover degrade much more quickly in marginal lands than in more favoured regions, if unsuitable land use practices are adopted. Once the land has become degraded it is much more difficult than in other regions to restore fertility and productivity.

Today, under the pressure of increased human and animal populations and changes in land use systems, almost all the world's marginal lands are in danger and it is becoming increasingly difficult to ensure the maintenance of their long-term biological productivity.

The "Dust Bowl" of the 1930s in the United States was the result of improper extension of dry crop cultivation into the dry belt of the Middle West. Nobody spoke of desertification at that time. Yet it was exactly that and a first example in modern times of large-scale, catastrophic soil degradation.

A large industrialized country such as the United States can survive if a small percentage of its surface becomes unproductive, barren land. What, however, if the same situation occurs in a Sahelian country? What if large portions of a poor country become affected by desertification due to over-grazing and extension of rainfed cultivation into areas which are not suited to it? Then the ecological problem becomes a pressing human one as millions of people see the whole basis of their livelihood placed in jeopardy.

For the countries south of the Sahara, it is estimated that an area of some 685 million hectares is affected by severe desertification (out of a total land surface for Africa of 3,011 million hectares), and eighty million people are already directly affected by a fall in the productivity of the lands from which they live.

For all these reasons a large part of the research being carried out under Unesco's Man and the Biosphere (MAB) Programme is concentrated on halting improper land use while at the same time increasing food production in marginal lands of such distinct regions as the Sahel and eastern Africa, the altiplanos of the Andes, the Hindu Kush-Himalaya mountains or the traditional rangelands of North Africa (see box opposite). Nor does MAB neglect the problems for the environment and for society which may derive from uncontrolled use of marginal lands in developed countries. In

Holding the desert at bay

MAB-related research in southern Tunisia

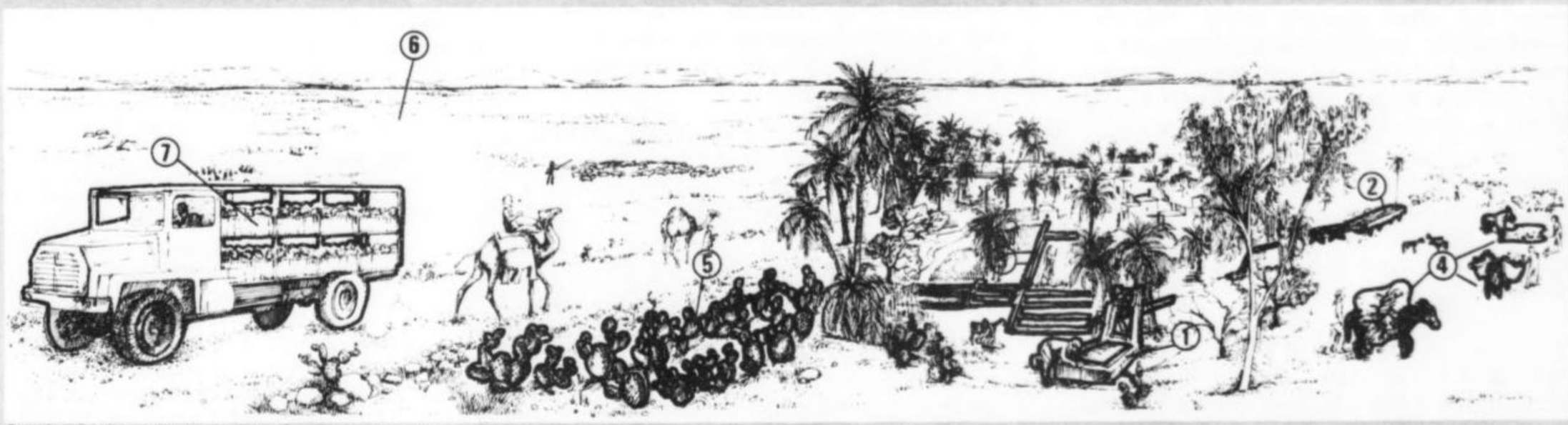
The Problem: to improve the productivity of rangelands and of livestock raising and to control the extension of rainfed agriculture by the preparation and introduction of integrated land management plans in former Tunisian grazing lands where a combination of human and livestock population increases, a shrinking land base, agricultural expansion and mechanization has led to a serious problem of land degradation and even desertification.

In central and southern Tunisia annual rainfall varies from 350 mm in the north to less than 100 mm in the south. Traditionally these areas were exploited by nomadic herdsmen. Overgrazing was always a problem, particularly in the south, but it was alleviated by flock reductions in times of longer than usual drought. Since the beginning of this century, however, the population has increased considerably and has become more sedentary. Large areas of former grazing lands are now being cultivated with cereal and tree crops (olives, almonds). At the same time, as the human population grew so too did the number of sheep and goats, thereby exerting further pressure on the land. Finally, the introduction of disc ploughing during the last twenty-five years has accelerated the erosion of shallow soils.

The Projects: as early as 1969, the Tunisian authorities, realizing the importance for the country of solving its critical environmental and developmental problems, launched a programme of integrated ecological research. During the early 1970s, two MAB-related activities were undertaken in this field. In the first project, Tunisian authorities and specialists collaborated mainly with French specialists and institutions with services and major funding being provided by the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO) and Unesco. The second project originated under the International Biological Programme and brought mainly United States specialists from the U.S. Desert Biome Project to work alongside their Tunisian colleagues.

To maintain the continuity of this work, the Tunisian Government in 1977 established a National Institute of Arid Regions to which it entrusted the task of promoting and coordinating MAB-type research and of training research workers and technicians. At present the Institute, with support from the United Nations Environment Programme (UNEP) and Unesco's MAB Programme, is carrying out studies on such problems as reseeding and camel-raising.

The Results: data acquired in the UNDP/FAO/Unesco project were used to develop land management plans which integrate rangeland herding, rainfall agriculture and irrigation agriculture based on oases. Rangeland maps were prepared showing the major range units and other features such as annual and seasonal primary productivity and optimal period of use, on which rational land use planning can in part be based. Methods for increasing animal production were improved through various forage and animal husbandry experiments. For the Zougrata area, simulation models were worked out to predict trends in productivity. Another example of the results concerns the importance of the composition of flocks. Studies of mixed flocks of half sheep and half goats showed that goats consumed more of the tallest vegetation group (shrubs) than in an only-goat flock. Sheep consume larger amounts of the annual and biennial species when in a mixed flock than in all-sheep flocks. From a practical standpoint, this suggests that the goat is not the nuisance animal that it is generally considered to be. Man himself, by associating goats with sheep, has made the grazing by goats more destructive. Similar results have been found in other parts of the world.



Drawing *Etudes et Planification des Communications,* Unesco Courier

Drawing, above, illustrates an integrated land development plan, now being adopted in parts of southern Tunisia, which enables traditionally separate land use systems to complement each other. A densely populated oasis, with a permanent supply of water (1) sufficient for irrigation agriculture and to meet the needs of people and animals, forms the hub around which stock-raising activities in the surrounding rangelands revolve. Water is piped out to a watering trough (2) for the animals of the rangelands where water is a precious resource. Crops (3) such as cereals, vegetables, and alfalfa for fodder are grown under irrigation, providing food for the population of the oasis and the herdsmen of the rangelands. Supplementary forage (4) from intensive agriculture can be a life-saver for the rangeland herds during the annual dry season and in times of extended drought. Supplementary forage may also be provided by growing well-adapted plants, such as non-spiny cactus (5), which require no irrigation. The herdsmen—once nomadic but now tending to settle in or on the outskirts of the oasis—earn most of their income from the cattle they graze (6) over an area extending very many kilometres around the oasis. Combined oasis/rangeland developments are being integrated into the national economy and their products (7) sold on regional and national markets.

some parts of the European Alps excessive tourist development has already started to destroy the very landscapes on which the tourist industry is based. To deal with these problems comprehensive, interdisciplinary research aimed at understanding and improving the complex man/environment interaction is required (see box this page).

To add to all their other difficulties, the marginal lands face a further problem which they share, but in a much more intense form, with the rest of the world—the problem of energy.

For about a third of mankind the energy crisis means a daily scramble to find the wood they need to cook their daily meal. Nine-tenths of the inhabitants of the world's poorest countries still depend on firewood as their principal fuel, and at least half of all the timber felled in the world is used as fuel for cooking or as a source of heat.

All too often, however, the growth in human population is outstripping the growth of new trees, and villagers in the arid and semi-arid regions of central Africa and Asia, in many parts of the Andes, and the Hindu Kush-Himalayas have to search farther and farther afield to satisfy their needs.

This constant search for firewood can, furthermore, have serious environmental consequences. Shrubs and trees play an important role in maintaining balanced functioning of arid and semi-arid ecosystems. They provide protection for the soil against the direct impact of rain, they provide shade for the lower vegetation, animals and people, they reduce evaporation and they ensure better water regulation within the soil. In addition, the leaves and branches that fall from them enrich the humus content of the upper soil and they provide a habitat for birds which themselves play an important role in the functioning of the ecosystem. Over-use of trees and shrubs for firewood and other human needs such as housing and fencing sets in motion a process which leads from soil erosion and degradation to desertification.

Energy problems in the high mountain areas are often equally acute, though, paradoxically, through the development of hydro-electric schemes, they have, in many parts of the Andes and the Hindu Kush-Himalaya ranges for example, become a major source of energy for urban, industrial and rural development in the densely populated valley systems, coastal areas and plains below. In the actual mountain areas themselves rural electrification has often not been developed.

In these areas the energy problem is intrinsically the same as that in the rural areas of the arid and semi-arid zones, and wood is likely to remain the principal fuel for at least another two decades. The deforestation of mountain slopes that this entails also involves serious environmental consequences—soil erosion, the silting up of hydro-electric dams and, eventually, increasingly severe flooding of the plains below.

Solutions to the energy problems of marginal lands are fairly simple to envisage but extremely difficult to implement. Trees, after all, are a renewable resource and a logical response to the fuel shortage is to plant more fast-growing trees for use as firewood. Yet not enough tree-planting schemes have been implemented and when they have been introduced their effect has often been wiped out by population growth.

Attempts are also being made to encourage the use of alternative sources of energy: bio-gas, solar and wind energy, for example. But a great deal more research leading to a considerable reduction in cost and technological simplification is needed on these alternatives before they can make a substantial contribution.

The drama of the deterioration of the world's marginal lands is that if it is allowed to continue it may well result in the creation of a vast army of marginal people, living in totally inacceptable conditions. Deteriorating ecological systems have a logic of their own; the damage builds up little by little until the day comes when the system collapses. A combined international effort is necessary if the marginal lands of the world are to avoid this fate.

■ **Mohamed Ayyad and Gisbert Glaser**

Mountain scenarios

The Pays d'Enhaut project—Switzerland

The Problem: **to anticipate and minimize the possible environmental effects of various forms of economic development in an alpine region of Switzerland.**

The Project: **despite considerable tourist development over recent years, the Pays d'Enhaut, a mountain district of the Vaud Canton of Switzerland, unlike many other alpine regions, has succeeded in maintaining a viable upland agriculture and an unspoilt natural environment. But important changes are imminent. The lack of suitable employment for young people may lead to depopulation of the area and a subsequent degradation of the environment, on this occasion due to lack of human intervention. Alternatively, large-scale construction of hotels and chalets for tourists, with the infrastructure of roads, etc., that this would necessitate, might solve the employment problem but could result in serious deterioration of the environment.**

The regional development programme adopted in 1978 aims to find an acceptable middle way which would maintain the local population at its present level by the development of tourist facilities. To achieve this objective, however, would involve the creation of some thirty kilometres of ski pistes, the setting aside of one hundred hectares as a skiing area, and the provision of about 4,000 additional beds for tourists.

The MAB study now under way is an attempt to forecast the possible effects of various levels and types of development and the precautions needed to maintain the equilibrium of the environment.

The people of the Pays d'Enhaut are actively involved in the research. A Project MAB, Pays d'Enhaut Association has been formed which includes representatives of every social level of the community.

Fourteen research units have been established to examine specific aspects of the problem and to improve understanding of the Pays d'Enhaut considered as a system.

The Results: **research by the MAB team only began in 1980 so it is too early to announce concrete results. Four possible scenarios for the future are, however, already emerging and their implications for the environment will be presented to the decision-makers and the local population. Very roughly these scenarios may be described as follows :**

1. **A traditionalist approach. This tends towards the maintenance of the** status quo, **with somewhat more emphasis being placed on the development of farming activities, but with mechanization kept to the strict minimum. Tourism would remain a modest supplementary, mainly summertime, activity, the tourist being lodged** en pension **or in small hotels.**

2. **A modernistic approach. This is resolutely aimed at maximizing income for the local population by developing to the maximum all the resources of the region. Tourism would become the major economic sector and some agricultural land would be abandoned.**

3. **An ''ecological'' approach. The thinking here is dominated by a desire to pass on to future generations a biologically intact region in which pollution, erosion, etc., are kept to a minimum. The tourist would be tolerated only in so far as he was prepared to respect nature. Building and private transport would be severely restricted. Agricultural methods would be aimed at low energy consumption and the use of ''soft'' technology.**

4. **A ''peripheral'' approach. This sees the district serving the larger urban centres around it in various ways. Above all, the Pays d'Enhaut would be a sort of country retreat for the people of these centres—which would involve the building of a large number of individual secondary residences and good access roads and the provision of facilities for leisure activities.**

Cities in crisis

by Valerio Giacomini

WHAT constitutes the "ideal city"? For medieval European man, the goal was an earthly reflection of a heavenly model—the *City of God*. For the utopian thinkers of the Renaissance it was a suitable setting for the realization of their own grand designs. During the past century or more, architects and city planners have applied a great deal of intelligence and, on occasion, genius to the solution of this age-old question.

The same period, however, has also seen the expansion of cities on such a scale that they now seem to defy all attempts at improvement or control. These great centres of human settlement, activity and culture once radiated in all directions—sometimes to the very ends of the earth—the light of science, art, philosophy and technical progress. Today, they accumulate, and cast about them with the same profligacy, the shadows of disorder, degradation and waste.

The problems of great cities have thus become one of the major issues, if not *the* issue of our age. The enormity of the difficulties faced by decision-makers in their attempts to contain and control the processes which threaten the quality of the human habitat is such that renewed efforts are urgently required.

As long as human communities formed an integral part of the natural order, their physical and biological stability was in great measure assured by the self-regulatory process of nature itself; their specific unity was enveloped in the greater whole. But the progressive alienation of the natural order, which has reached its apogee in today's metropolises, has weakened this relationship to the point of rupture.

What is called for is not a "return to nature", but the development of an entirely new pattern of interrelationships. Once, man was merely a pupil in nature's school; now his power over the environment, for better or for worse, is supreme. There is no ecosystem which has not to some extent been subjected to interference by man in his pursuit of personal gratification or immediate gain.

The urban ecosystem, the environment which has been most affected by the interventions of modern man, offers a unique opportunity for the pooling of efforts in the task of humanizing science and mobilizing its resources in the service of society. The way in which these ecosystems function is being studied within a major project of the Man and the Biosphere Programme.

Scientists investigating urban phenomena should acknowledge with humility that they are only scratching the surface of a subject of extreme complexity. Considered in isolation, the research findings of, for example, a botanist concerning the flora of the city, of a zoologist concerning its bird life or of a hydrologist concerning its groundwater are of fragmentary and limited significance; but if they are linked together in logical fashion and, more particularly, if these findings are pooled in an investigation of more general structures and functions, they acquire an unexpected and sometimes fundamental significance for the understanding of the system in its entirety.

The so-called "systems approach" has been widely utilized, but attention has until now all too frequently concentrated on the sub-systems and sub-sub-systems in which life processes are organized, while the macrostructures which constitute the only setting in which human problems can be properly appreciated remain neglected.

Within the MAB Programme it is advocated that, if the systems approach is to be truly effective, it should engage responsibilities on a far larger scale than in the past. The major problems of the human habitat, which have become extremely critical in urban centres, no longer fall within the exclusive purview of specific disciplines or technologies; nor are they a matter for science and technology alone. Their dimensions are such that they resist limited, specialized efforts to solve them. All the resources of human culture must be brought together in a vast collective undertaking, and focussed on these problems in their entirety.

If there is hope for the future, it can only lie in a new spirit of solidarity between all the scientific disciplines, between spokesmen for culture in all its different forms, between all the inhabitants of the city itself, and between decision-makers at every level.

Like the world of nature itself, the city should be put to use in the service of individual and collective human needs. ■

VALERIO GIACOMINI. *This article is based on a longer study written by Professor Giacomini, of Italy, shortly before his untimely death on 5 January 1981. An eminent botanist, he was professor at the Instituto Botanico, Citta Universitaria, Rome, and chairman of the Italian MAB National Committee. He was the originator and leader of the MAB Rome Project, a major ecological study of the Italian capital launched in 1977.*

Photo Ivan Farkas © Fotogram, Paris

The imposing façade of St. Peter's Basilica, Rome, forms the backcloth to this scene of traffic congestion, one of the symptoms of the problems facing major cities today. Rome is the subject of a large-scale ecological study launched in 1977 by the Italian MAB National Committee. The study, which began as a study of energy flows in the city, now encompasses seventeen themes, ranging from environmental perception to modelling of the entire urban system. Many groups, including university research workers, government institutions such as the national electricity corporation, and the local population are directly involved. The Municipality of Rome has decided to create a Centre for the Study of Urban Problems, to provide a more permanent framework for the project and to ensure the wide participation of all the cultural and technical segments of the local population. The Municipality also envisages that the Centre will eventually have a wider international role to play in this field of research.

The ecology of megalopolis

by Stephen Boyden and John Celecia

MEXICO City: thirty million inhabitants. Tokyo and Sao Paulo: over twenty-six million. These dramatic figures are taken from the latest United Nations statistical projections for the year 2000. According to the same projections, over half the people on earth are likely to be living in urban areas by the end of this century (as against today's 40 per cent), and eighteen cities in developing countries will each have a population of over ten million. The problems of inner city decay in the industrialized world pale to insignificance beside those of the mushrooming cities in developing countries.

During much of this century urbanization has been a worldwide phenomenon. Today, however, under the pressure of the world population explosion, it is taking place on such an unprecedented scale that cities are spreading an ever-widening circle of devastation around them as they seek the resources they need, and courting the risk of virtually drowning in their own wastes.

The exodus from the countryside to the towns is particularly dramatic in the developing world, where it is taking place much more rapidly and against a background of much higher population growth than the urbanization process in the industrialized countries, which was usually gradual enough to allow the emergence of institutions capable of coping with the problems of transformation.

Why should rural populations be attracted to cities? It might be thought that rural poverty, especially when set against the backcloth of grandiose natural surroundings, is less brutal than poverty in the slums and shantytowns spawned by Third World cities. The fact is that the former is just as deadly, though less conspicuous, than the latter. People gravitate to the cities because they expect to find there better job opportunities and social possibilities, availability of food, water, health and educational facilities. And they are right to the extent that average income in the city is usually far higher than it is in the rural economy. Cities are centres of consumption on such a large scale that the resourceful may find a form of sustenance which is a better alternative than near-starvation in the countryside. For the rural masses of the developing world, then, migration to towns and cities is spurred by the need for survival.

The cruel irony is that this imbalance between town and country, reinforced by the concentration of public investment in urban areas, is now contributing to urban growth on such a scale that it becomes impossible to maintain the quality of life of city-dwellers. Another irony: the problem of cities bursting at the seams is further compounded by demographic growth *within their boundaries* when child mortality rates fall as a result of the provision of better health care facilities. It is little wonder that the question is being asked in some quarters whether cities are approaching, or have already reached, the limits of expansion.

Although the problems of providing food, lodging, water and health facilities and jobs for tomorrow's urban multitudes will be immense, the signs are that the world is not yet ready to meet the impact of the urban explosion. Even when governments do establish mechanisms and institutions for dealing with urbanization they often seem unable to perceive the problem as a whole. In the last ten years, an ecological approach to the study of urban settlements has been evolved within the Man and the Biosphere Programme. The main objective of these MAB activities, which have so far led to the implementation of over 60 field projects, is to help improve the basis for the rational planning of human settlements by promoting research on the complex interrelationships between man, his urban environment, and the interactions between urban settlements and their hinterland.

Good town and city planners have always used ecological devices, but in the past often tended to deal with problems in isolation and put forward recommendations which, though ecologically sound in themselves, ceased to be so when considered within the context of the wider urban system. To take one simple example : a green belt is created to provide a city with "lungs". This is a desirable thing in itself, but unless other measures are taken at the same time, it may simply attract new settlements and more traffic, so that new

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roads have to be built. The hypothetical green belt thus defeats its own object. In contrast to this piecemeal approach an integrated, interdisciplinary "ecosystem approach" to urban studies is advocated within MAB, with special attention being given to the "flows" of food, energy, materials, people, information and other elements through cities.

One of the distinctive characteristics of cities is that they depend on food surpluses produced elsewhere. In fact urbanization first began with the development of agricultural surpluses made possible by technical advances such as irrigation and the use of draught animals. Urban growth was limited until relatively recently by the capacity of the immediate hinterland to provide the city's basic food needs. But whereas in the past cities drew on nearby land for their food supplies, in the modern world they import from distant countries. Their hinterland is now worldwide. This reliance on food supplies from distant sources illustrates the fragility and the vulnerability of the urban ecosystem.

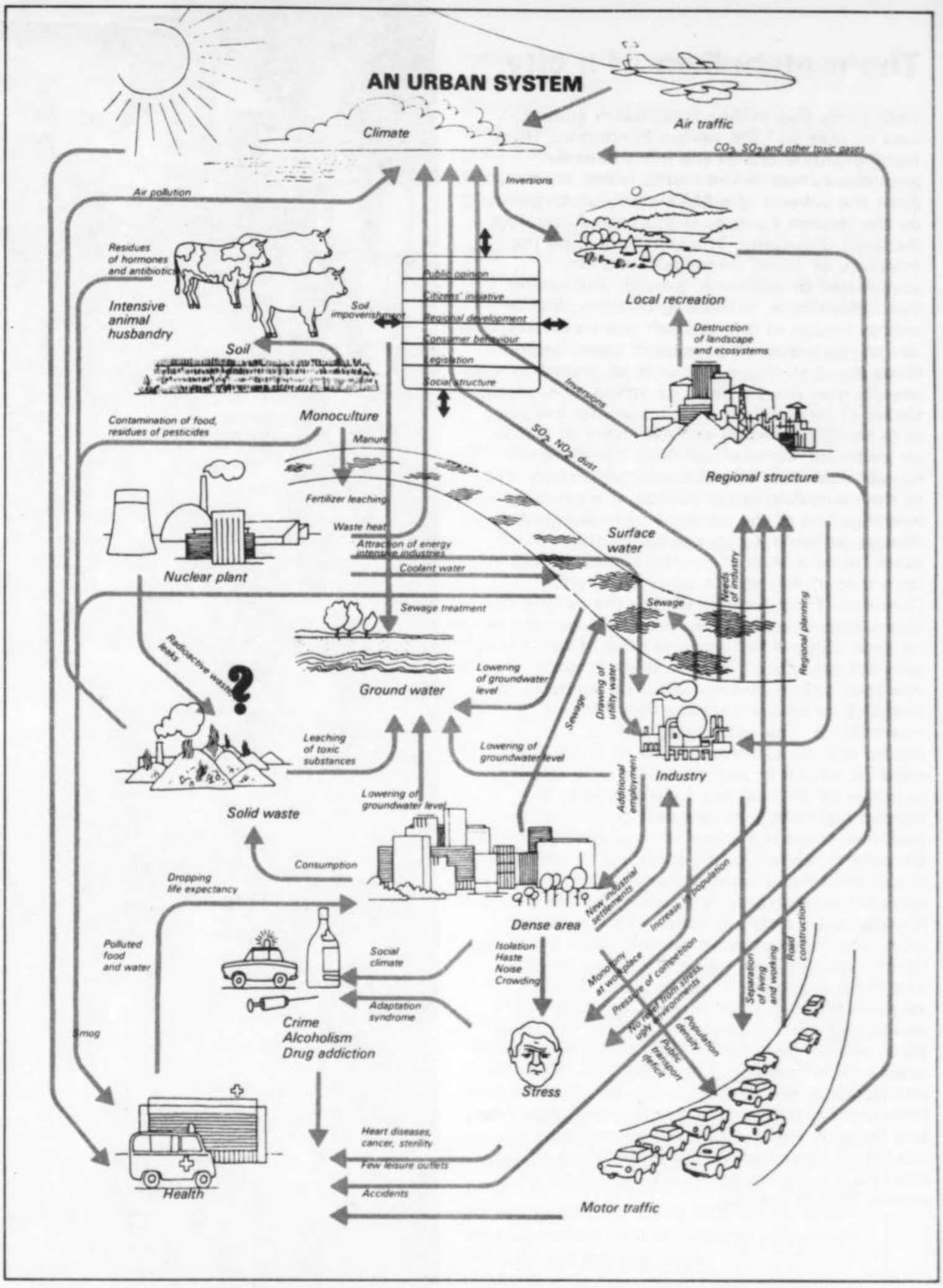
For those who live in cities, such dependence has several implications. The increasing cost of food production, the cost of transportation, distribution and processing, and the consequent high energy demands make food more expensive for the city-dweller than for his rural counterpart. The urban poor are hardest hit. They are potentially vulnerable to serious malnutrition because not only are they unable to pay spiralling market prices for food, but because in urban conditions they are often deprived of the opportunity to grow their own.

One answer to this problem, particularly in developing countries, might be to give agriculture prominence in national development plans, so that a flourishing agricultural base could be built up to support decentralized, labour-intensive industries that would process farm products and produce goods useful to small farmers. This in turn would bolster agricultural production and help reduce rural migration. Meanwhile, for millions of the urban poor, the potential capacity of the urban system to produce food may be a factor on which their survival may hinge. The agricultural skills of the migrant population can be effectively harnessed with improved land use and the establishment of intensive cultivation plots, roof gardens and other productive units. Composting, urban forestry, irrigation systems using alternative energy systems for pumping, aviculture and fish-farming are some of the practices meriting greater attention. Another step forward would be the development of accessible techniques for food storage and preservation in order to counteract the dramatic losses of food in areas where it is most wanting. In fact in urban slums in many parts of the world people are already displaying great resourcefulness in producing food and recycling materials, and this should be taken into account by planners.

Although cities began with the development of agricultural surpluses, it was the harnessing of the energy from fossil fuels as the basis of modern industry that gave real impetus to urban growth. This brought more rapid, complicated and profound changes to cities than any that had occurred in their millennia of history.

The study of energy flows, with which the Man and the Biosphere Programme is particularly concerned, is an important yardstick which can help us to understand the urban ecosystem because energy is required for all activities. The study of the energy pattern of a society touches on all aspects of its development and draws attention to ecologically significant changes that are taking place. The pattern of the use of energy from sources other than human or animal muscle has particularly profound implications, for it reflects the pattern of machine use. This in turn is related to the quality of the air people breathe, the levels of noise they experience, the size of the enterprise for which they work, and even to the time they spend travelling to work or with their families. Such factors may also affect the structure of their families, the extent to which they practise skills or exercise responsibility, or the amount of variety or monotony in their lives. Many of these aspects of people's lives are difficult or impossible to measure, because they are intangible, but a truly comprehensive approach to the study or planning of urban systems, as being encouraged by MAB, must pay full attention to them.

A MAB study on Hong Kong highlighted the massive consumption of energy which is another salient characteristic of the urban system. The city's energy consumption doubled in the ten years from 1961 to 1971, whereas population did not greatly increase. This phenomenon is part of a global trend which accompanies industrialization. Before the industrial era, muscle power was the main source of energy, and consequently the rate of energy use paralleled the rate of increase in population. This is no longer the



Graphic © Studiengruppe für Biologie und Umwelt, GmbH, Munich

This model of an urban system is taken from *Urban Systems in Crisis,* a publication based on an important study carried out by the Munich-based Study Group for Biology and Environment as part of the contribution of the Federal Republic of Germany to MAB project 11 on human settlements. It illustrates the complexity of the interactions that occur between the various components of an urban system and between an urban settlement and its hinterland. Although based on a study of a specific area, the Frankfurt-am-Main region, the model is applicable also to other environments. It was developed as a tool for decision-makers and as an aid in understanding and planning human living spaces.

The metabolism of a city

With some five million inhabitants squeezed into an area of 1,046 square kilometres, Hong Kong (right) is one of the most densely populated areas in the world. It has recently been the subject of a MAB study undertaken by the Human Ecology Unit of the Australian National University. The Unit examined the interplay of urban forces within a city committed to economic growth, increasing industrialization, increasing consumption of energy (much of it imported) and increasing use of resources. The research team found in Hong Kong all those elements of growth which usually give rise to "big-city stress" (neuroses, states of tension and psychosomatic maladies in general) caused by endless rivers of traffic, air pollution, vertical buildings dwarfing the human scale and massive overpopulation. Yet, to their surprise, in the course of a general investigation of the patterns of health and disease in Hong Kong, members of the MAB team found a level of mental illness no higher than that of Australia's spacious capital, Canberra. They concluded that the people of Hong Kong were shielded from big-city stress by their cultural background, one of those less tangible aspects of city life that research workers, policy-makers and planners tend to overlook or ignore because they are not quantifiable. The upbringing of the predominantly Chinese people of Hong Kong remains rooted in traditional Chinese culture, in a way of life that has long accepted as normal high levels of population density. In addition, there is a sense of involvement in the Chinese extended family tradition. Working together in Hong Kong's many small family workshops and factories, family members and friends retain a strong sense of purpose and unity and these positive factors make a definite contribution to well-being and good health. The MAB approach to research on urban settlements is to look at them as ecosystems, examining the complex interactions that take place within them rather than studying specific problems in isolation. This technique is illustrated by the diagrammatic representation (below) of the flow of important materials into and through Hong Kong, which might be described as a chart of the metabolism of the city. All the figures given are expressed in metric tonnes per day.

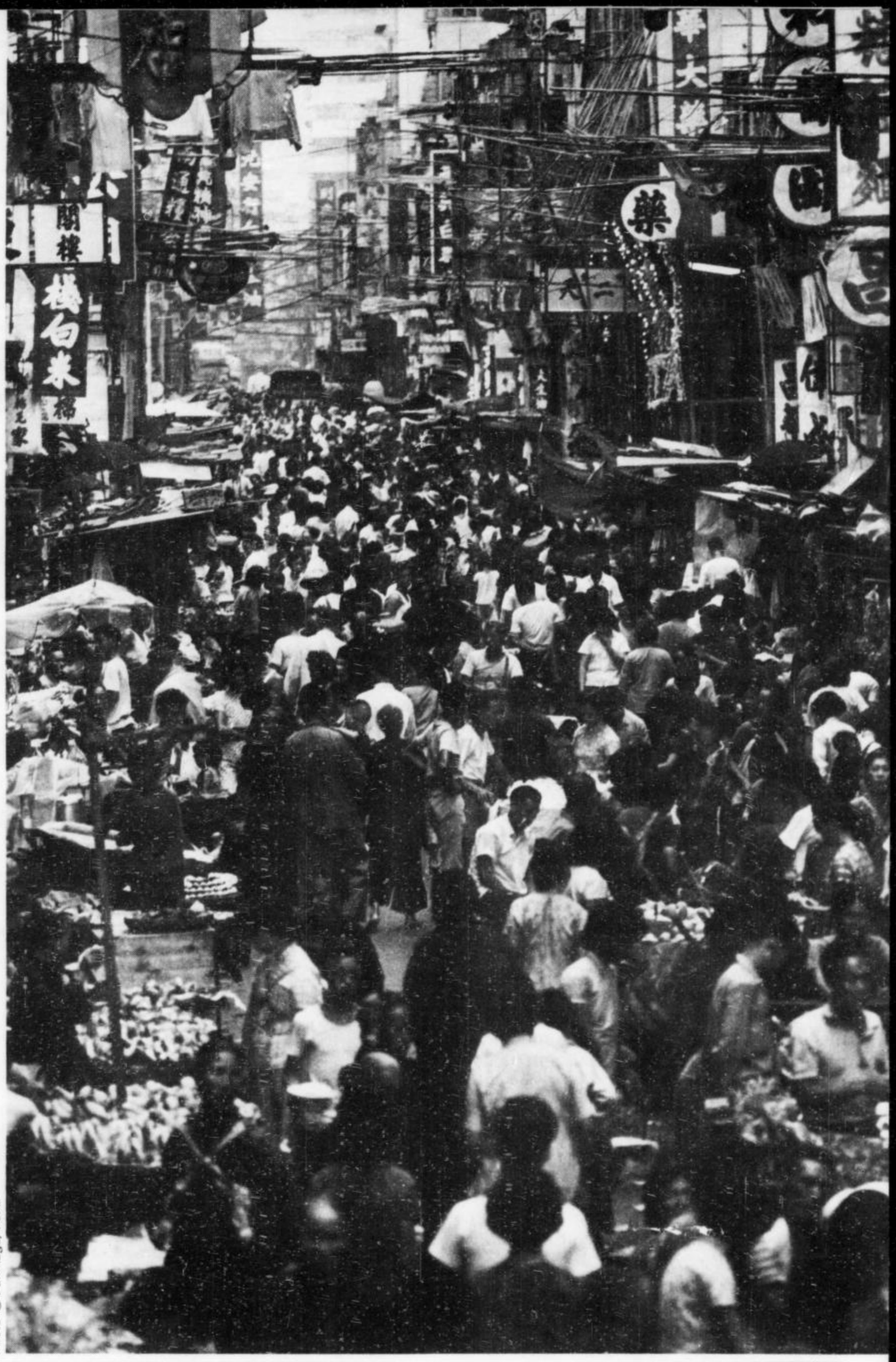
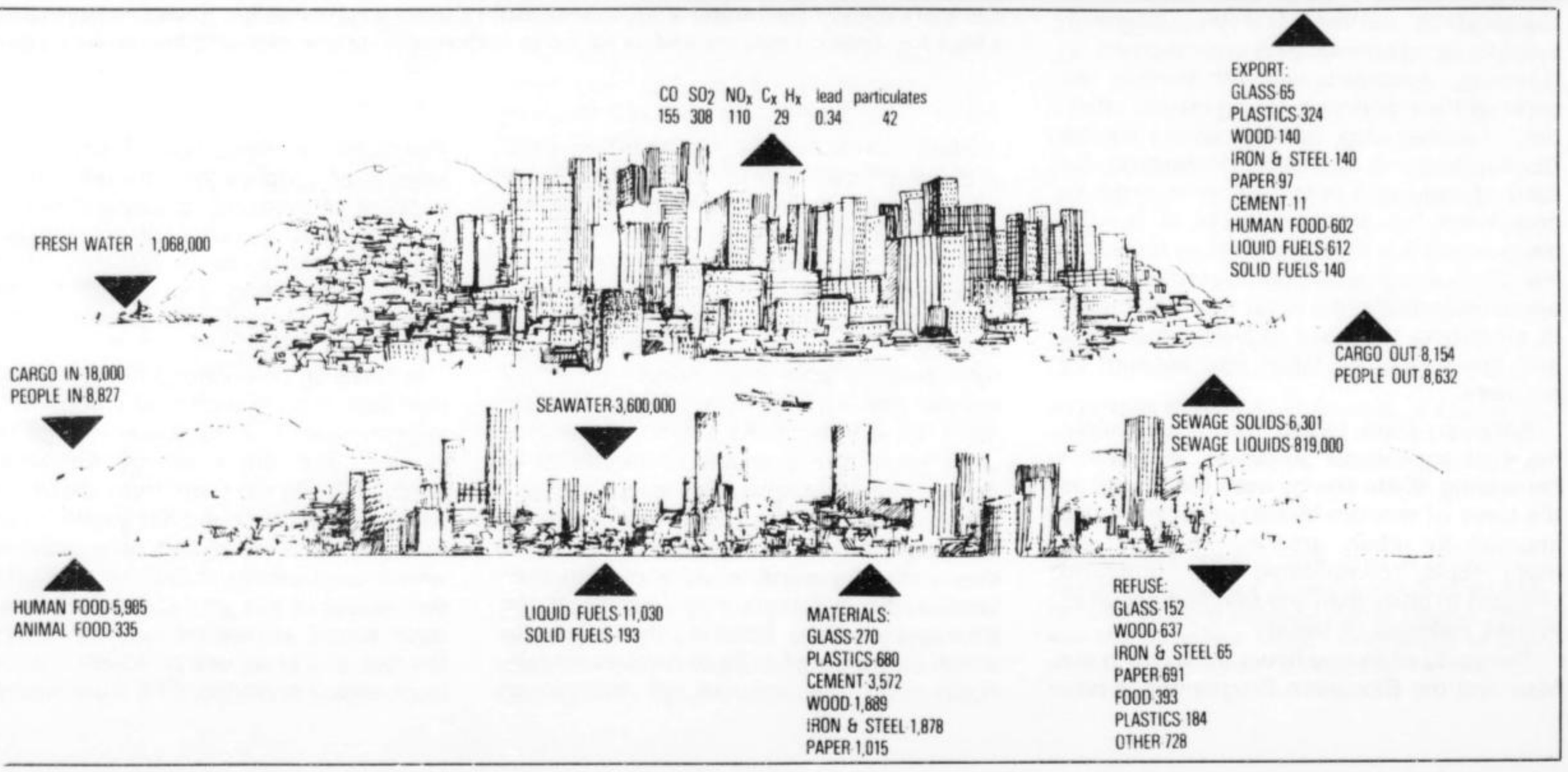


Photo © Parimage, Paris



Graphic Études et Planification des Communications, Unesco Courier

case today when the amount of energy being used is doubling about twice as fast as the population. Extra-somatic energy use in Hong Kong, although it doubled, was only about one-tenth of what it is in the United States and one-fifth of what it is in Australia.

As demand rises, cities face energy problems which are not unlike those of food supply: the fuel must either come from the surrounding countryside or from imports.

In many developing countries the vast majority of the urban poor rely on traditional fuels such as wood and charcoal. To obtain their supplies they must either bring devastation to nearby woods and forests, or else buy fuels such as kerosene or bottled gas, which they can ill afford. Another alternative, buying their wood and charcoal from merchants, means that the ecological damage is done even further away from the city through the exploitation of distant forests.

The urban poor use less energy than the rural poor. There are two reasons for this. The first is that the need to buy fuel encourages them to use as little as possible; the second is that a kerosene stove is more efficient than a countryman's open fire. However, this energy efficiency is dependent on increasingly costly imported fuel, and so there is an urgent need for alternative energy systems.

The world thus faces a phenomenon of mushrooming urban growth whose implications are colossal. Sectoral approaches have only brought a limited understanding of the human system on the one hand and the natural system on the other. We must accept the challenge of interdisciplinarity, of harmonizing the goals of economic development with environmental concerns and human well-being. Within the Man and the Biosphere Programme a number of countries have developed such integrative approaches to improve understanding of urban ecosystems and produce information for planning and decision-making.

Unfortunately such efforts are still very dispersed, dependent on limited human and financial resources, and constrained by institutions which maintain a sectoral approach.

In many cases the institutions and scientists participating in this work have had a multiplier effect on the modest resources available. It is to be hoped that an increased awareness of the problems of urbanization at international, national and institutional level will lead to greater support for these pioneering efforts.

■ **Stephen Boyden and John Celecia**

Change without tears

The Lae project—Papua New Guinea

The Problem: how to guide urban and regional planning in ways that help, firstly, to mitigate the adverse social effects that may accompany the process of urbanization, secondly, to conserve energy demand for which increases dramatically with urbanization and, thirdly, to provide future energy requirements from renewable resources.

The Project: examines the ecological problems associated with the development of Lae, the major industrial city of Papua New Guinea, which has grown rapidly in the past decade. From 1966 to 1971 the urban population increased by sixteen per cent each year and in the following six years grew by five per cent annually. By October 1977 the population had reached 45,000.

The MAB study, undertaken by a research team drawn from the Human Ecology Unit of the Australian National University, started in 1976 and ended its field work in 1979. Particular attention was paid to a comparison of living conditions for a group of highlanders from the Chimbu province, both in their rural villages and the urban setting to which many of them have migrated. Sub-projects examined the repercussions of cash-cropping of coffee and the spread of the market economy; changes in social behaviour during the process of urbanization; rural and urban food habits and beliefs; and energy flow for Lae and Chimbu. The aim was to lay the basis of an ecologically sound energy future and create an urban system in Lae compatible with both the social and biological requirements of human well-being.

The Results: the comparative food study shows that attitudes to food are changing rapidly. Even the most remote hinterland has felt the effect of the city's market economy through the influence of the village stores which now import foodstuffs and consumer goods from Lae. In the village group under study malnutrition among children was high. Even though there are enough greens and other foods available to provide an adequate diet, cultural preferences for the sweet potato (which is high in unrefined carbohydrate and low in proteins) are strong. In the village the incidence of gastro-intestinal and respiratory infections was also high, as was childhood morbidity and mortality. Degenerative diseases appeared virtually absent.

In the urban environment, however, the pattern is changing more rapidly. The urban diet is rich in animal protein, children grow faster, and malnutrition is half that of the village. Even so, the diet is more refined, sweeter, and higher in fat, and tends to increase susceptibility to degenerative diseases of the heart, diabetes, and dental caries.

The position of women in society has been affected. The movement of men from village to city to work as labourers forced the women left behind to fill traditional male roles as well as their own. However the resultant stress was cushioned by the close-knit social groupings of village life. Less fortunate were those women who accompanied their husbands. Dependent on the husbands' earnings for food they could no longer use their skills in food gardening and animal husbandry and frequently suffered alienation. Indeed many of the social problems identified by the study team have stemmed from the change to a cash economy which has cut across traditional village patterns of wealth and power.

Studies on energy flow and waste disposal have led to practical measures for conserving energy. One example is the use of sawdust, market residues and other resources of "waste energy" for producing compost. In 1978 the Lae City Council established the first 120 of a planned 1,500 intensively composted allotment gardens. Subsequently a design of a city-wide composting programme to produce 11,000 tons per annum was prepared and construction is now proceeding. A 60,000 gallon bioconversion system was commissioned in November 1979 as a pilot project for the recovery of sewage as sludge for composting, as liquid fertilizer for broad-acre agriculture, and as methane-rich gas for industry and transportation.

Allotment gardens kept fertile by compost from domestic and industrial refuse and sewage sludge will relieve the burden of indiscriminate gardening on the adjacent hills, which has resulted in devastating erosion. A project has been designed to re-plant the hillsides, for conservation and rehabilitation, for firewood, and for subsistence agroforestry using nitrogen-fixing trees and vegetables in areas zoned for each purpose.

Another practical follow-up is that the MAB project triggered the formulation of the Government's national energy-policy, and a strategy of implementation, which was adopted by the National Cabinet in February 1979. National Alcohol Fuel and Wood Fuel Programmes, plus wind energy, direct solar heating, cooling and electricity, and large-scale biogas projects are planned.

The Lae project is therefore an example of a MAB field project which has produced applicable scientific results which have subsequently been applied. One key to the success of the project was the focus of the research project on problems of priority concern to local and central government. In effect local and regional policy-makers and administrators were involved at all stages of the research, from project formulation to transfer of results.

Conservation for development

by Walter Lusigi and Jane Robertson

"THE biosphere is like a self-regenerating cake, and conservation is the conduct of our affairs so that we can have our cake and eat it too. As long as certain bits of the cake are not consumed and consumption of the rest of it is kept within certain limits, the cake will renew itself and provide for continuing consumption. For people to gain a decent livelihood from the earth without undermining its capacity to go on supporting them, they must conserve the biosphere."

This image of the biosphere, evoked by Robert Allen in his book *How to Save the World*, neatly summarizes current attitudes towards conservation and underlines how much the concept has evolved over the years.

Four centuries before the Christian era Plato was complaining that the mountains of Greece were being stripped of their trees. He was saddened to see the beauty of his homeland marred. Others who followed him were less concerned with beauty than with practical matters, with natural resources considered as commodities useful for specific purposes. The Romans who argued for the conservation of certain forested areas wanted to ensure a constant supply of wood for the construction of warships; in the Middle Ages yew trees were planted and protected solely to provide longbows for archers, and the monarchs and great landowners of Europe set aside forests for their personal hunting pleasures and as a source of game for their banqueting tables. Many of these royal forests—the Bialowieza Forest in Poland and the New Forest in England are but two examples—stand to this day, vestiges of the ubiquitous mixed forest that once covered this part of the world.

This was conservation of a sort. But the humbler people of those times, albeit unconsciously, were practising a perhaps more important form of conservation throughout their lives. For it must not be forgotten that the traditional land use practices of farmer and peasant existed in harmonious balance with the natural environment. The elaborate terraces on hillsides, whether in Indonesia, in Italy or in the Andes, the primitive but efficient irrigation systems in arid and semi-arid areas, the open animal ranges of the African savannah and the intricate jigsaw puzzles of field and hedge in north-western France were all created and maintained by man, and his constant action provided a large variety of habitats for a whole range of wild and domestic animals, insects, plants, reptiles and birdlife which evolved within the framework of these man-made agro-ecosystems. In Asia, respect for wild animals and plant life was perhaps even more developed and, indeed, was raised to the level of dogma in certain religions.

In the western world, the industrial revolution radically altered this situation of balance and harmony with nature. The new industrial towns encroached on agricultural land and subsistence farming dwindled as farmers developed new methods to make the land more productive in order to feed the growing urban populations.

Gradually, during the eighteenth and nineteenth centuries, a reaction set in against the waste and degradation of the land these changes involved. In the United States of America the wholesale destruction of natural resources and the massacre of birds and animals such as the passenger pigeon and the Great Plains buffalo precipitated the formation of a conservation movement. In 1864, the Yosemite Valley, with its beautiful landscapes and awe-inspiring groves of giant sequoias, was designated a protected area, administered

Below, view of the Glacier National Park, Montana, one of the 36 protected areas in the USA designated as biosphere reserves. With reserves ranging from the Aleutian Island National Wildlife Refuge to the Everglades National Park, the U.S. biosphere reserve network now covers every biogeographical province within the country's territory.

by the State of California, and in 1872 the Yellowstone region of Wyoming was proclaimed a national park, but under Federal supervision. These two parks, reserved for man's recreation and aesthetic pleasure, were the forerunners not only of a national system of parks but also of similar initiatives throughout the world and by the 1920s national parks were to be found in every continent.

The birth of the national parks movement marked a major step forward in the evolution of the concept of conservation, the importance of which has become increasingly evident during this century as industrial growth and the population explosion place greater and greater pressure on the world's natural resources.

However, for a number of reasons, the national park concept has not always travelled well. In many cases the mistake has been made of believing that conservation methods can be transplanted directly without being adjusted to suit the new environment and with no attempt being made to assess local cultural values, local fears and local needs.

This applies, for example, in Africa. Living in balance with the environment has always been an integral component of African culture. From childhood the African is taught to co-exist with the natural world around him and that he is part and parcel of the system. African religions refer specifically to the preservation of natural things and it is taboo to kill more than is needed for survival.

The communal land ownership system was also designed to enhance this living in balance with nature. In pastoral societies wildlife was regarded as "second cattle" and was especially used during droughts when cattle were scarce. Throughout the years Africans evolved a form of co-existence with the wildlife around them which permitted both to survive.

The era of colonization and settlement and the two world wars that followed did much to destroy the sense of harmony with nature that had been part of the African heritage for so many years. The Kenyan experience provides a classic example.

During both world wars there was large-scale slaughter of wildlife, with the meat being used to feed prisoners of war. After the war, a concentrated effort was made to develop agriculture in Kenya. Wild animals were regarded as pests, destroying crops and competing with domestic livestock for pasture; it was thought to be in the best interests of the country to kill off as many wild animals as possible and this policy was ruthlessly implemented.

It was against this background that the Society for the Preservation of the Fauna of the Empire was formed to protect the dwindling wildlife population. The Society immediately demanded some control over the indiscriminate slaughter of wildlife, and the establishment of national parks and reserves. First a system of reserves covering virtually the whole of the country was established, and game could be hunted only on permit. Later, in 1946, the first national park was established, to be quickly followed by others. These were game preserves where no settlement or hunting were allowed.

But the needs of Africans in Kenya received little consideration in this period. First, the European settlers had ousted many Africans from their traditional homelands. Then the introduction of laws which allowed hunting by permit only made their normal subsistence hunting illegal. Finally the creation of national parks reduced still further the land available to them. Thus, for the African, the national parks have been one of the mechanisms that forced him from his home, and the penalties imposed for infringement of the game laws have solidified his negative attitude toward wildlife and its conservation.

Meanwhile, ironically enough, the parks are becoming less and less suitable as habitats for wildlife, primarily because of measures originally taken to preserve them for that purpose. The parks of Kenya were founded on the premise that nature would be allowed to take its course and no human intervention would be allowed. But most of the parks were established on derived grasslands, which had been partly maintained as grassland by fire. In the absence of fire, the land is reverting to woody vegetation which is unsuitable for game adapted to open plains.

The Kenya experience has been considered at some length, firstly, because it is an experience which, apart from specific details, it shares with many other countries in Africa and elsewhere, and, secondly, because it highlights the need for a further evolution in our thinking about conservation.

If conservation is to win acceptance from local populations it must take into account cultural mores, and the long-standing ties between the population and the natural environment. Planning must be based on an evaluation of cultural, political and socio-economic as well as ecological factors, and conservation must take local human needs into consideration, in both the short and the long term. It must offer a solution to the apparent contradiction between conservation and development needs.

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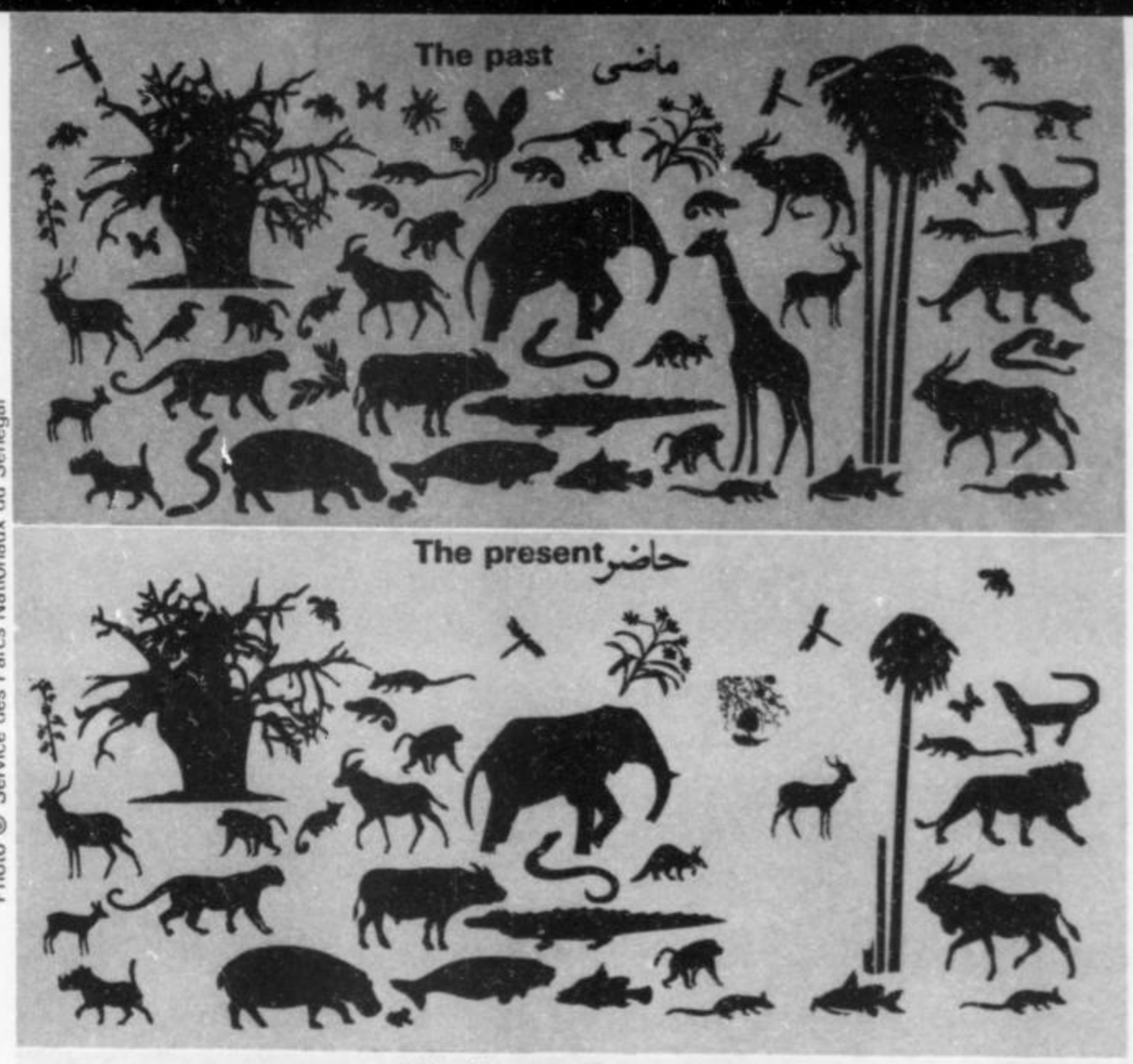

Photo © Service des Parcs Nationaux du Senegal

This poster is used by Senegal's National Parks Service to publicize the cause of wildlife protection.

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Biosphere reserves

by Vladimir Sokolov and Piotr Gounin

Photo A. Lessniak © APN, Moscow

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A bird that dislikes flying, prefers to run and climb trees and hides its food in its burrow like a mammal (the saxaul jay), a bird that can sing like a lark, chatter like a magpie, whistle like a man and bray like a donkey (the wheatear), a type of sparrow that never drinks, the world's biggest lizard (the "sand crocodile" or monitor lizard which can attain a length of one and a half metres)—these are some of the stranger denizens of the huge (34,600 hectares) Repetek Biosphere Reserve in the desertic Karakum region of the USSR.

The Soviet Union has a proud record of nature conservation with one hundred and twenty-five State reserves covering a total area of over eight million hectares. Seven of these State reserves, including Repetek, have been designated as biosphere reserves forming part of Unesco's Man and the Biosphere (MAB) network of biosphere reserves. The six other reserves are: The Berezina Reserve, in the Byelorussian SSR—a low-lying area of alluvial sands and glacial moraines almost entirely covered with broadleaf and spruce forests typical of the Russian plain; The Caucasus Reserve, located in the western part of the

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Left, a stretch of the Repetek biosphere reserve, situated in the Kara-Kum desert, and two of the bird species found there: above left, the Egyptian Vulture *(Neophron percnopterus)* and, above right, the Isabelline Wheatear *(Oenanthe isabellina)*.

Biosphere reserves are protected areas where nature conservation is combined with basic scientific research, climatic and pollution observation and measurement, and environmental education. Drawing, right, illustrates the various functions of a biosphere reserve, here set in a northern temperate ecosystem. The *Core zone* (1) contains a representative example of the major natural ecosystem of the region, in this case mixed and coniferous upland forest. The core zone is strictly protected and serves as a background area or control for studying man's impact on the natural environment. The *Buffer zone* (2) surrounds the core zone and serves as a protective screen. It contains areas in which the ecosystem has been modified by such human activities as agriculture, timber extraction and cattle raising. Facilities and activities in the buffer zone as illustrated here include (A) traditional land use; (B) carefully controlled recreation of a non-destructive, non-polluting type; (C) facilities for basic research, laboratories for measurement, scientific analysis, etc.; (D) experimental plots used to study specific plants under controlled conditions; (E) environmental monitoring, including continuous observations of rainfall, temperature and air pollution levels; (F) teaching the general public about environmental problems and nature conservation.

Photo USSR MAB National Committee

in the USSR

Caucasus mountains—a typical mountain landscape covering all altitudinal zones and including broad-leafed forests, fir forests, glaciers and alpine meadows; The Prioksko-Terrasny Reserve, in the basin of the Oka river—a good example of the ecosystem of the East European plain; The Sary-Chelek Reserve, in the Chathal mountain range in south-west Tian-Chan—it has an extremely diverse and complex vegetation ranging from nut-fruit forest, spruce forest and mountain grasslands and its fauna includes the white-clawed bear and snow leopard; The Sikhote-Alin Reserve, along the coast of the Sea of Japan—its vegetation is dominated by coniferous and broad-leafed forests, but includes several relict and endemic species; The Central Chernozem Reserve, in the central Russian uplands on the borders of the Kursk and Belgorod regions—a characteristic oak-steppe forest of the European part of the USSR, containing rare examples of undisturbed meadow-steppe.

All seven biosphere reserves had previously been functioning as State natural reserves for quite a considerable period (the reserve at Repetek, for example, was founded in 1928) and have long records of observations on the basic components of nature. This facilitated the first stage of ecological monitoring—taking inventories of plants, animals, micro-organisms, ecosystems and processes. Another advantage was the existence of research units within or close to these reserves.

Thus the Prioksko-Terrasny biosphere reserve includes the Biosphere Station of the Agrochemistry and Pedology Institute of the USSR Academy of Sciences, and the Sand Desert Station of the Desert Research Institute of the Turkmenian Academy of Sciences is situated in the Repetek reserve.

The seven biosphere reserves naturally do not cover all the variety of nature in the USSR and the USSR National Committee for MAB is conducting preparatory work for the establishment of a second series of biosphere reserves, first of all in Siberia, Kazakhstan and Central Asia where the rate of development requires rapid, profound and detailed investigation.

Photo E. Arbuzov © APN, Moscow

The Prioksko-Terrasny biosphere reserve, in the Oka river basin about 120 kilometres south-west of Moscow.

Every biosphere reserve is charged not only with the general task of monitoring and studying the effects of pollution on the natural environment but also with more specific tasks such as observing the influence of various types of economic activities on the local ecosystems on a regional scale. In addition the biosphere reserves may be used as study grounds for the training of personnel for other countries.

Training courses of this type are conducted at the Repetek reserve, where participants from developing countries are instructed and trained in various aspects of nature conservation as applied to deserts. It is worth mentioning that not long ago deserts were considered to be "errors of nature" and not worth conserving, whereas in fact they are extremely rich in biological resources.

The Repetek reserve in the USSR is so far the only biosphere reserve in the temperate deserts of Central Asia and its functioning as well as the establishment of other reserves in this climatic zone is of the utmost importance for the rational use of natural communities in the desert.

Thus the objectives of the MAB biosphere network are highly complex and require a further strengthening of co-operation at every level: national, bilateral, regional and global. Man has reached a stage in his development when his activity has to be commensurate with the capacities of nature. Researchers throughout the world have a priority task—to learn to use the resources of the biosphere without upsetting its balance. ■

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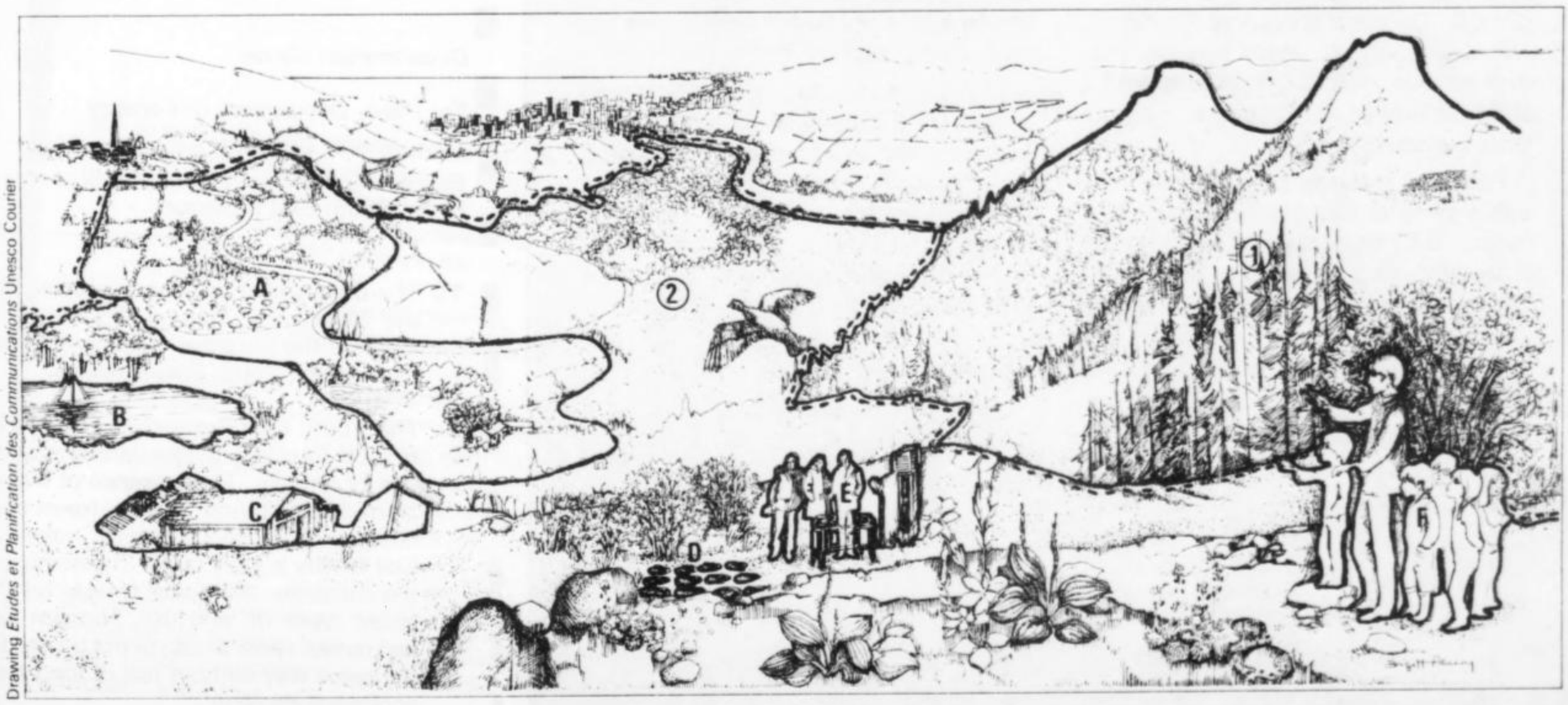
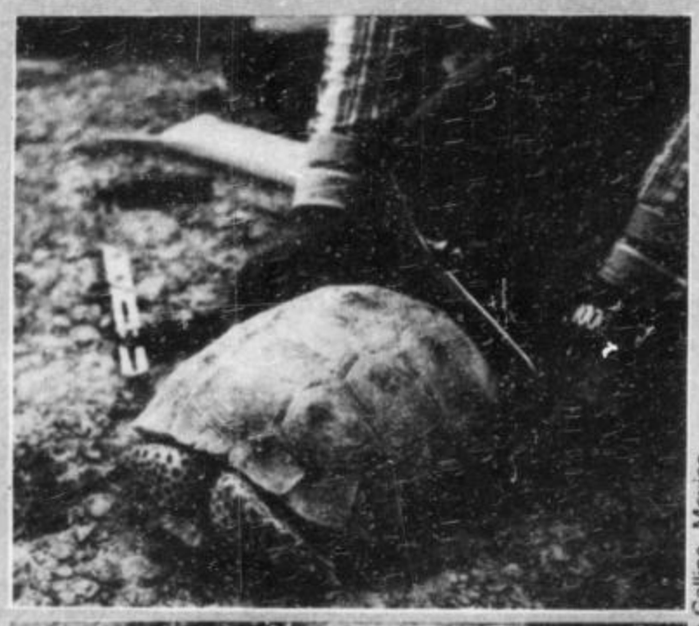
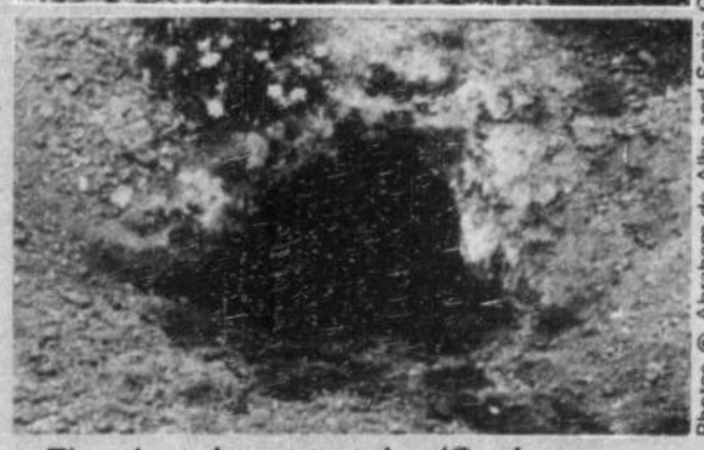


Drawing *Etudes et Planification des Communications* Unesco Courier

Poachers turned gamekeepers

The Mapimí biosphere reserve experiment





Photos © Abraham de Alba and Sonia Gallina, Mexico

The giant desert tortoise *(Gopherus flavomarginatus)* has been saved from almost certain extinction by the establishment of the Mapimí biosphere reserve in the State of Durango, Mexico. The entrance to its burrow is shaped in the distinctive outline of its shell.

The Problem: to reconcile the seemingly conflicting demands of development and conservation within a semi-desert basin known as the Bolson of Mapimí, situated in the State of Durango in north-central Mexico, an area with a surprisingly rich variety of plant life and animals including such rare species as the lynx, the cougar, the black-tailed deer, the wild turkey and the great desert tortoise.

The Project: in 1974, the Mexican authorities decided to buy up a tract of land in Mapimí to be set aside as a biosphere reserve devoted to nature conservation and scientific research. The site of the reserve lies within a semi-desert basin of several hundred thousand hectares which is the exclusive habitat of the endangered desert tortoise, Gopherus flavomarginatus.

Field work at Mapimí started in early 1975 with a study of flora and vegetation which revealed the tremendous ecological diversity of the area. As a follow-up to these initial studies, others were begun on the native animal communities and on the ecological effects of cattle grazing. At the same time, researchers from the Mexican Institute of Ecology carried out an information-demonstration-persuasion campaign with the people of Mapimí, showing them, for example, how small-scale, inexpensive irrigation practices could give higher fodder yields and explaining why hunting should be controlled and certain species protected.

The peasants and stockmen quickly realized that they could only benefit from the establishment of the biosphere reserve and agreed to work with the scientists in a large area surrounding the conservation zone owned by ranchers and ejidos (peasant collective enterprises).

The Results: in 1981, Mapimí is a highly successful example of how to integrate conservation, research and development. Because of the vulnerability of the main food crops—maize and beans—to prolonged drought and parasite pests, research has been focussed on diversifying food crops and improving stock raising methods, including the introduction of a new variety of non-spiny pear cactus as forage. Production of fruit and vegetables is now high enough to provide an exportable surplus and range management research has resulted in the drawing up of guidelines, not only in Mexico, but in arid areas elsewhere.

A great deal has been learned about the specialized desert-living plants and animals. Endangered species are now protected by the people themselves—the surest means of protection that exists. Although protected by law before the creation of the reserve, the giant desert tortoise, for example, was tracked down for food. Ecologists told the people of Mapimí that there would be no tortoises left if hunting continued and convinced them that an alternative source of protein could be obtained through rational cattle ranching. The former poachers have now turned gamekeepers and themselves protect the desert tortoise.

So successful has the Mapimí project proved to be that Rosendo Aguilera, a stock farmer in Mapimí and an enthusiastic supporter of the project, is now visiting a biosphere reserve at Donana, in southern Spain near Seville, an area sharing similar problems, to explain the methods that have brought new hope and prosperity to Mapimí.

The Desert Research Laboratory in the Mapimí biosphere reserve, Mexico.

Getting the message across

MUCH scientific research produces information which can be useful to a variety of non-scientific audiences. The key is to communicate that information in a form which is adapted to the interests and needs of each audience. Technical information on environmental problems, for example, needs to be "translated" in order to be understandable to resource planners and managers, teachers, students, children and others, all of whom can benefit from having such information made available to them.

Four graphic presentations on the functioning of a tropical forest are presented below. In each case, the same information is depicted differently for scientists, decision-makers, students and children. Other effective means for communicating scientific information are audio-visual programmes, posters, and exhibits.

Jeanne Damlamian
Unesco MAB Secretariat

Information for decision-makers

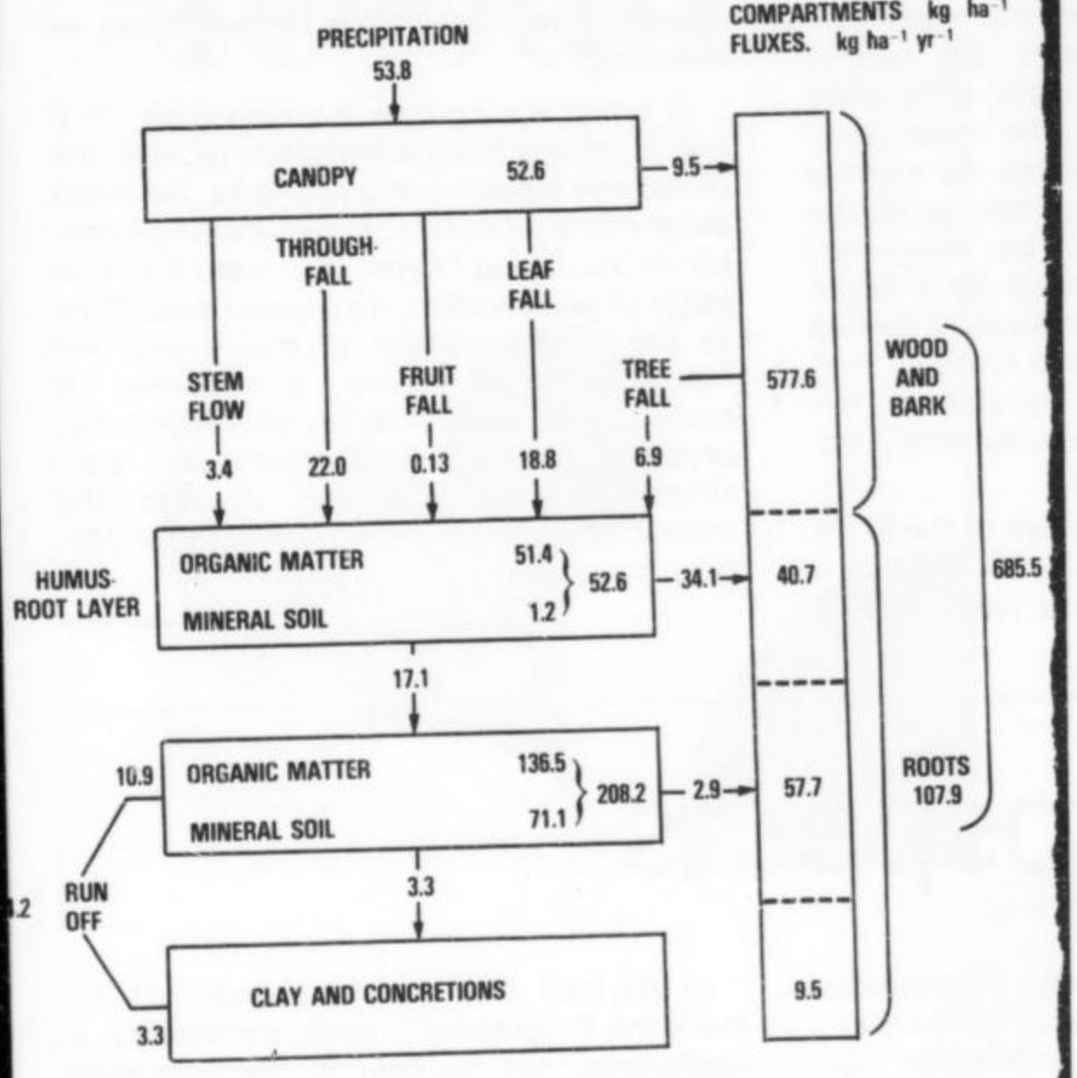
Departmental Memo

To: Head, Department of Forestry
From: Chief, Technical Assessment Unit
Subject: Guidelines for land development in the South East Province

1. The Department has been requested by the Ministry of Natural Resources to evaluate the potential for land development of the South East Province.

2. The South East Province is covered by tropical forests with low density population of farmers. The presence of a large biomass of "natural" tropical forest does not guarantee rich economic potential. Soil fertility is a key factor in determining the suitability of tropical forests for different types of land use. Nutrient rich and nutrient poor areas cannot be used in the same way without risk of long-term ecological damage.

Information for scientists



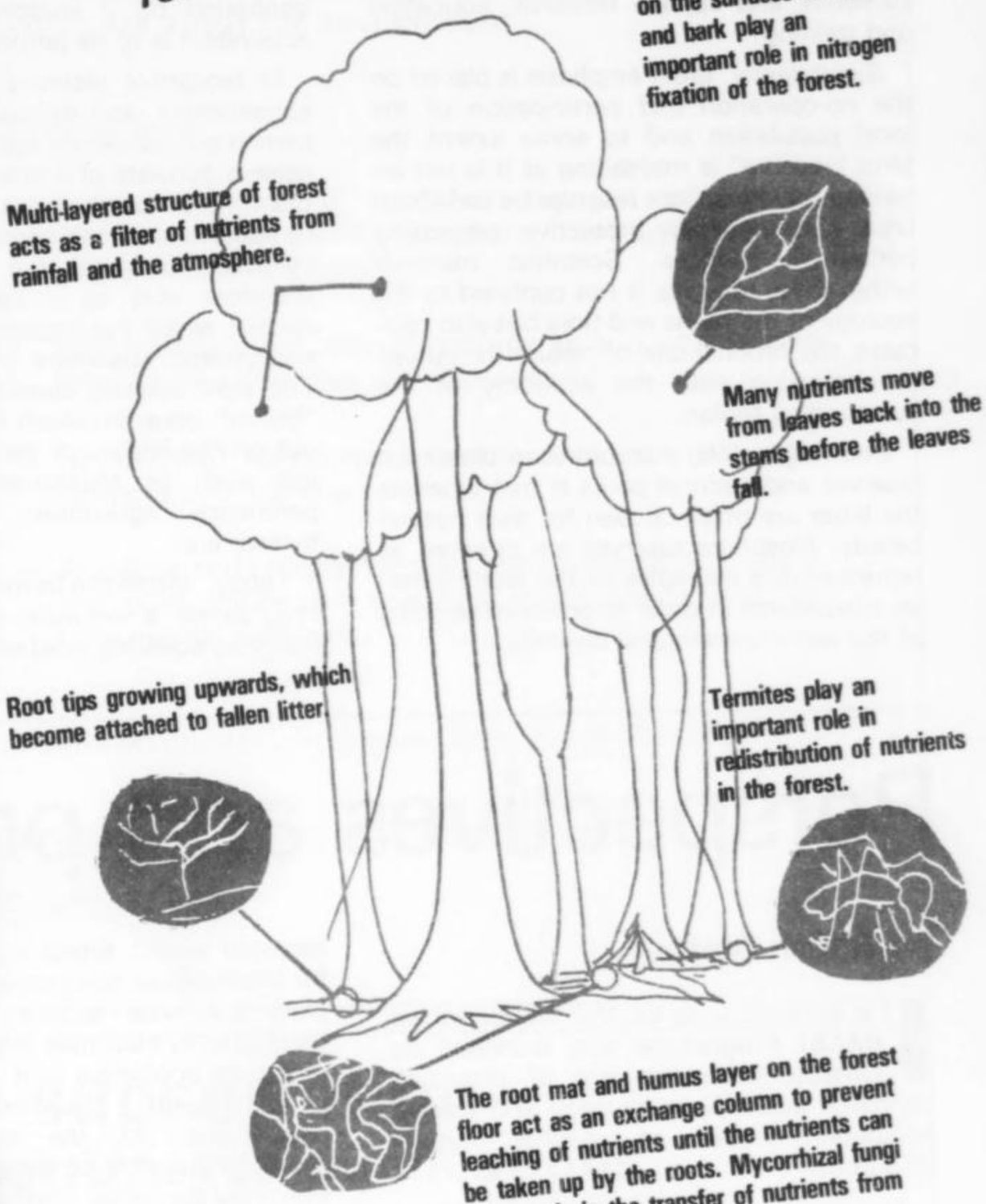
Compartment model showing composite budget of calcium, potassium and magnesium in the tropical moist evergreen forest at San Carlos de Rio Negro, Venezuela.

3. Land capability surveys and social impact assessments of South East Province have been conducted by the National Scientific Research Centre.

9. In sum, it is recommended that a diversity of land uses be maintained in South East Province, as follows:
   - Concentration of *agricultural investment* (cocoa, sugar cane) on the nutrient rich soils in the *North*.
   - *Intensive forest production* in the *West*, with logging intensity adjusted to forest type.
   - Improvement of existing systems of *agro-forestry* on nutrient poor soils in the *East* and *South*, by working with local farmers to introduce new mixes of fruit trees and crops used successfully under similar conditions elsewhere in the country.

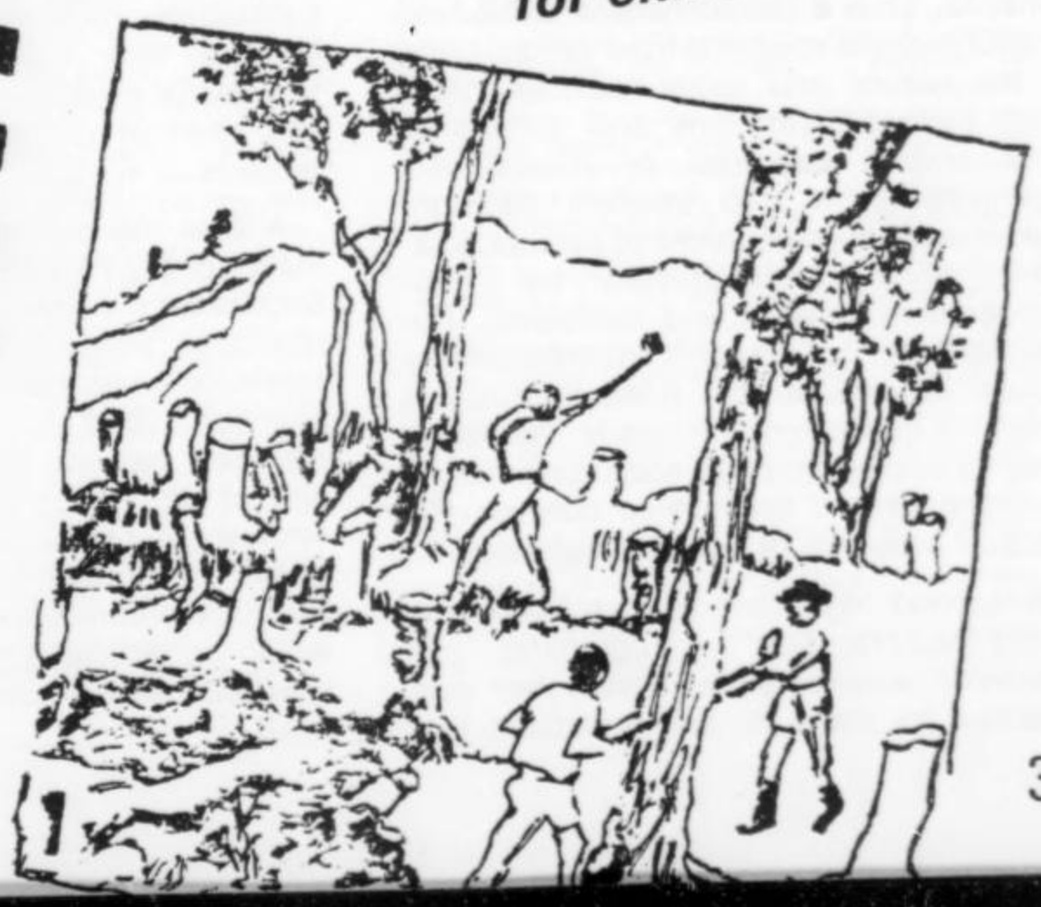
Throughout the province, blocks of forest should be set aside to help control potential insect pests, to provide plants for medicinal purposes and other products.

Information for students



The functioning of tropical rain forests with limited soil nutrients depends largely on input by rain, and the ability of forest plants to use this source of nutrition. Productivity in the undisturbed forest is maintained by very well developed mechanisms for efficient recycling of the nutrients stored in its biomass. All of these mechanisms are associated with the living forest. When the land is cleared for agricultural purposes, these nutrient conserving mechanisms are destroyed and the ecosystem rapidly loses its productive capacity.

Information for children



CONTINUED FROM PAGE 29

The biosphere reserve concept developed within Unesco's Man and the Biosphere (MAB) Programme contains the elements of this alternative approach. This concept attempts to combine the preservation of ecological and genetic diversity with fundamental and applied research, education and training.

Significantly, great emphasis is placed on the co-operation and participation of the local population and to some extent the term "reserve" is misleading as it is not intended that biosphere reserves be forbidden areas surrounded by protective, separating barbed-wire fences. Scientific research within these reserves is not confined to the ecology of the fauna and flora but also concerns the rational use of natural resources in connexion with the economy of the surrounding region.

One major difference between biosphere reserves and national parks is that whereas the latter are often chosen for their natural beauty, biosphere reserves are selected as representative examples of the world's major ecosystems in order to preserve samples of the world's ecological diversity.

As man has altered and transformed the face of the world from time immemorial, by definition biosphere reserves must include man-modified ecosystems where certain forms of human intervention constitute important ecological factors which must be continued on a sustainable basis if the ecosystem is to be perpetuated.

In biosphere reserves a combination of conservation and manipulative research is carried out. Generally speaking, a biosphere reserve consists of a strictly protected central "core" zone in which the natural development of the ecosystem, untouched by man, is monitored. The core zone therefore acts as a baseline or control against which the impact of man on similar ecosystems elsewhere can be compared. The core zone is surrounded by a larger "buffer" zone in which research is carried out on the impact of various types of land use such as traditional agriculture, experimental agriculture, recreational activities, etc.

Today, within the framework of the MAB Programme a network of 193 biosphere reserves, covering most of the world's major biomes, has been established in 50 countries. The results of research carried out within these reserves is exchanged through MAB's computerized Information System. In some cases even closer co-operation is achieved through the "twinning" of reserves covering the same type of ecosystem but in different parts of the world.

This is the case, for example of the Berezinsky reserve in the USSR and the Isle Royale National Park (which is also a biosphere reserve) in the United States of America.

A biosphere reserve is much more than just another conservation unit. Indeed, the biosphere reserve concept marks the latest stage in the evolution of the concept of conservation. Going beyond the important first stage of preservation, it involves research into the wider question of man's use and modification of entire ecosystems. It resolves the apparent contradiction between conservation and development and constitutes a new approach towards the maintenance of mankind's biological life-support system.

■ **Walter Lusigi and Jane Robertson**

Perspectives and prospects

by Ralph Slatyer

IT is ten years since the Man and Biosphere (MAB) Programme was launched by Unesco, with the aim of providing improved scientific knowledge and trained personnel needed to manage natural resources.

The Programme has passed through a lengthy period of planning and testing out new approaches to co-operative research, into its present stage of active operational projects in real field situations. In each of the major themes of MAB there are now a number of comprehensive well-funded projects producing vital management-related information, and many more are emerging.

The ingredients which have been essential to the success of the Programme can now be seen more clearly than when it was first commenced.

A first ingredient is participation in a MAB project of the range of individuals and organizations that are affected by, or can help solve, the problems which the project contains. Thus a comprehensive MAB field project involves scientists from various areas of the natural and social sciences, often from various institutions and sometimes from several countries or international organizations. It also involves decision-makers and representatives of local populations which are affected by land-management policies and decisions. The development of such interdisciplinary groups has meant that basic information which is collected or made available, whether in the natural or social sciences, is co-ordinated and brought to bear on the practical problems of land management.

A second ingredient is that MAB is a "from-the-bottom-up" programme, in which individual countries decide their own priorities for research, and undertake that research within broad agreed frameworks for international co-operation. This helps explain the wide support that MAB has generated in countries spanning the whole range of ecological and geopolitical conditions found in the world. MAB is their programme. At the same time, this characteristic of MAB puts a special responsibility on countries. Until a particular country—either the government, or an institution in the country, or even an individual—starts a project, so far as MAB is concerned, nothing happens. There is no MAB project. So, there has to be a firm national commitment before a project gets off the ground. This helps ensure that the project is dealing with a problem having some ranking in national priorities.

A third ingredient has been the degree to which individual projects have attracted additional financial support once they have become established. The initial input of funds associated with the national commitment to each project has, in many cases, been catalysed by modest financial support from Unesco's regular budget to generate substantial additional support from both bilateral and multilateral sources. This substantial multiplier effect of MAB funds has been of critical importance to many projects.

A final ingredient has been the performance of the Paris-based international MAB Secretariat, a team of less than ten specialists assisted by a small number of scientists seconded periodically from Member States. Although each member of the team has specific responsibilities for a part of the programme, the degree of interpersonal interaction is such that the collective contribution is much greater than the sum of the individual efforts. In my view it would be difficult to overstress the role of the Secretariat in the present success of MAB.

In late 1981, MAB will be 10 years old. To mark the Programme's tenth anniversary, a conference will be held in September in Paris to review the progress that has been made, to evaluate shortcomings as well as achievements, and to point the way for the further evolution of the Programme.

It is, of course, too early to say what will be the result of this important exercise. However, it seems likely that MAB will continue to be based on an interdisciplinary, problem-oriented approach; that the Programme will resist the temptation of embracing everything and will remain concentrated on a few themes of priority importance; and that increased attention will be given to demonstrating the practical implications of the results of research, and to presenting these results in a form useful for decision-making and environmental education. I also expect that the international scientific community will play an increasing role in the Programme as important general principles concerned with land utilization emerge.

At the same time the Programme is likely to maintain its characteristics of a nationally-based international programme of research and training, rooted in the reality of priority problems as perceived at local and national levels. As such, I hope it will continue to play a distinctive part in the overall world-wide effort to tackle environmental and natural resources problems. ■

RALPH SLATYER, *Australia's ambassador and permanent delegate to Unesco, is president of the International Co-ordinating Council of Unesco's Man and the Biosphere (MAB) Programme. An expert on resource ecology, he retains his appointment as professor of environmental biology at the Australian National University, Canberra.*

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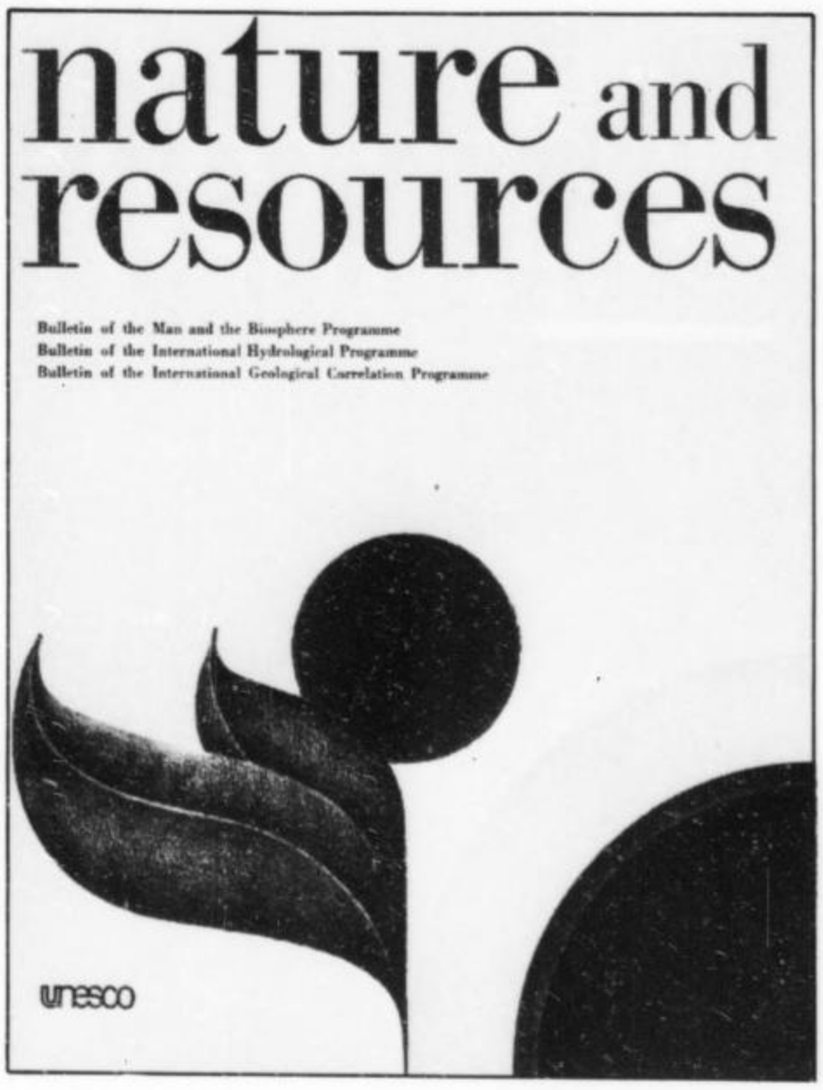

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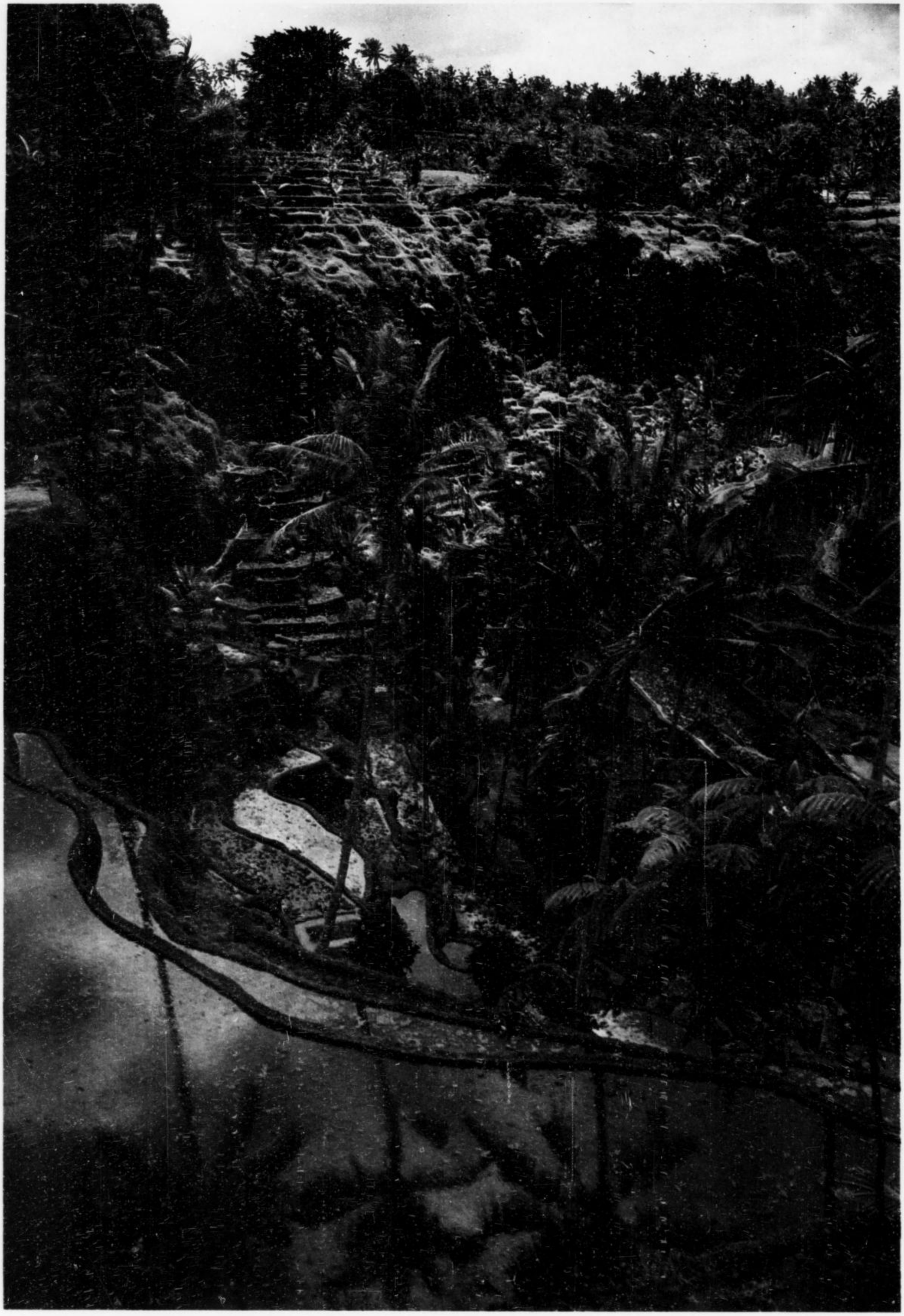

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In partnership with nature

Shaped by centuries-old irrigation techniques, these rice-terraces on the island of Bali (Indonesia) are an example of harmonious balance between traditional land use practices and the natural environment (see article page 28).